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A SHORT NOTE ON THE RELATION BETWEEN THE STATURE AND SITTING HEIGHT OF THE DIFFERENT HILL TRIBES OF TRAVANCORE

By B. K. Chatterji *and* G. D. Kumar

(*Paper received on 9th September, 1952*)

(Communicated by Dr. W. G. Griffiths)

During the winter of 1948-49, different settlements of the hill tribes of Travancore State were visited and the data on sitting height, stature, etc., were collected from among 140 Kannikars, 125 Uralis, 47 Paliyans, 31 Muthuvans, 37 Malapantarams, and 19 Kuravans.

The sitting height represents the distance between the vertex of the head and the plane touching the ischial tuberosities. In fact, as this part of the pelvis is covered with minimum tissue even in fat and muscular subjects and as the position of the ischial tuberosities is not changed by tilting of the pelvis to the same extent as pubis [1], therefore it gives a very important measurement and useful data for anthropological investigation.

At the time of taking measurements, particular care was taken that the vertebral column remained straight with the subject in sitting position, and trunk in upright position while the head of the subject kept in F.H. (Frankfort) horizontal plane.

The relation between the sitting height and the stature is best expressed by the sitting height-stature index, which is represented in terms of stature taken as 100. In such relationship, it has been observed that the sitting height is inverse to stature, i.e., with small stature the sitting height is relatively great and with tall stature sitting height is relatively less, even within the same race.

In the following Tables I and II, the mean values of the stature, the sitting height and the sitting height-stature indices and the different types of 'Cormic' indices [2] of the various tribes of Travancore and also a detailed comparison of the indices with other tribes and races of India and abroad have been tabulated.

Table I.

Shows the frequencies and the percentages of the different types of 'Cormic indices' of the various hill tribes of Travancore, viz., the Kannikars, Uralis, Malapantarams, Kuravans, Paliyans, Muthuvans and also of different groups of the Western Negrillos.[2]

Groups.	Brachycormic ($x-50·9$)		Metriocormic ($51-52·9$)		Macrocormic ($53-x$)	
	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage
Kannikar	81	57·86	53	37·86	6	4·28
Malapantaram ..	12	32·43	20	54·05	5	13·52
Kuravan	11	57·89	6	31·58	2	10·[illegible]
Paliyan	27	57·45	15	31·91	5	10·64
Muthuvan	20	64·52	8	25·81	3	9·67
Urali	61	48·80	55	44·00	9	7·20

[1] Bean, R. B., *American Journal Phys. Anthrop.*, Vol. V, 1921, pp. 349-50.
[2] Vallois, H. V., The Western Negrillos. *American Journ. Phys. Anthrop.*, Vol. XXVI, 1940, p. 457.

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TABLE I—*contd.*

Groups.	Brachycormic (x—50·9)		Metriocormic (51—52·9)		Macrocormic (53—x)	
	Freq.	Per-centage	Freq.	Per-centage	Freq.	Per-centage
Western Negrillos:						
BA BONGO ..	2	8·69	9	39·14	12	52·17
BA BINGA:						
Mindourou Ngoak ..	9	52·95	7	41·17	1	5·88
Gr. I of Poutrin ..	..	..	7	21·21	26	78·79
Gr. II of Poutrin ..	4	12·50	14	43·75	14	43·75

It would appear from Table I, that the percentages of Brachycormic types were the highest among all the tribes of Travancore except the Malapantarams in which case the highest percentage was noticed in Metriocormic types. It may be remarked that the lowest percentage was found in Macrocormic type among all the tribes.

It may also be remarked, as it appeared from the comparative table, that the percentages of Macrocormic types were the highest among the different groups of the Western Negrillos.

TABLE II.

Shows the comparative values of the mean, standard deviation and the coefficient of variation of the hill tribes of Travancore.

	Stature			Sitting height			Stature-sitting height index		
	Mean	S.D.	C.V.	Mean	S.D.	C.V.	Mean	S.D.	C.V.
Kanikar ..	1531·73	50·47	3·29	775·64	26·96	3·46	50·65	4·15	8·19
Urali ..	1544·52	66·29	4·29	786·99	35·95	4·57	51·14	1·48	2·89
Malapantaram ..	1555·08	56·38	3·63	797·19	33·07	4·15	51·25	2·03	3·96
Kuravan ..	1564·5[illegible]	[illegible]	3·23	796·00	28·52	3·58	50·92	1·32	2·59
Muthavan	1574·87	47·14	2·99	797·84	27·15	3·40	50·67	1·43	2·82
Paliyan ..	1597·43	56·40	3·53	811·34	25·35	3·12	50·81	1·00	1·97

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TABLE III.

Shows the comparative mean values of stature, sitting height and the sitting height-stature indices of different tribes and castes of India and abroad[1] with particular reference to the hill tribes of Travancore.

Tribe or Race	Total No. of individuals	Mean value of stature	Mean value of sitting height	Mean value of sitting height stature Index	Measured by
Kannikar ..	140	153·17	77·56	50·65	Chatterji & Kumar.
Urali ..	125	154·45	78·70	51·14	,,
Malapantaram	37	155·51	79·72	51·25	,,
Kuravan ..	19	156·45	79·60	50·92	,,
Muthuvan ..	31	157·49	79·78	50·67	,,
Paliyan ..	47	159·74	81·13	50·81	,,
Kannikar ..	10	153·6	78·7	51·2	Schmidt E.
Kurumbar ..	30	156·3	80·7	51·6	,,
Irular ..	14	155·4	80·7	51·9	,,
Kota ..	21	159·8	83·6	52·3	,,
Pulayar ..	11	157·8	81·2	51·5	,,
Toda ..	22	169·0	87·2	51·6	,,
Badaga ..	28	163·9	83·8	51·2	,,
Brahmin ..	17	162·6	84·4	51·8	,,
Semang ..	13	152·4	79·7	52·2	Annandale & Robinson.
Sakai ..	13	156·3	81·5	52·2	Knocker.
Javanese ..	17	157·1	82·5	52·5	Garrett.
Sudanese ..	37	159·1	83·0	52·0	,,
Tamil ..	44	161·8	82·0	50·8	Hagen.
Bushmen ..	14	155·3	77·0	49·5	Werner.
Toureg vassals	6	158·5	77·5	48·8	Verneau.
Negrito ..	231	146·8	74·3	50·6	Newton (Hrdlicka).
Niger ..	119	159·4	81·0	50·8	Tremearne.
Pigmy ..	12	158·4	83·5	52·8	Poutrin.
Filipinos ..	183	159·5	83·8	52·6	Bean.
Fuegians ..	25	157·7	83·0	52·7	Hyades & Deniker.
Ostiaks ..	127	156·5	83·6	53·3	Rudenko.
Samoyeds ..	53	156·8	84·8	54·1	,,
Australian ..	19	166·4	77·5	46·8	Spencer & Gillen.

A very close relationship has been found in the averages of the sitting height-stature indices among the Kannikars, Uralis, Kuruvans, Malapantarams, Muthuvans and Paliyans and other tribes of South India. It was also observed that a little difference was noticed in the averages of the said characters among the following people, viz., the Malapantaram, Kuravan, Muthuvan, Kurumbar, Kota, Toda, Badaga, Pulayar, and even the Brahmins of South India. But considerable difference was noticed when the averages of the indices of the hill tribes of Travancore were compared with that of the following tribes and races, viz., the Australian, Semang, Sakai, Bushmen, Toureg vassals, Sudanese, Ostiak and the Samoyeds of Siberia. It has been observed that the sitting height was found to be inverse to the stature and is relatively great or less in the case of small or large stature respectively, which is often true within the same race, but not so

[1] Bean R. B., *American Journal Phys. Anthrop.*, Vol. V, 1921, pp. 378–85.

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between different races. It was also observed that the Negroes regardless of stature, has a lower sitting height than any other people. Bardeen [1] from the standpoint of relative sitting height, observed that the South Indian tribes resemble to the Sakai and they possess a higher index of relative sitting height than the Australian and further added that from the standpoint of relative sitting height, the primitive groups of South Indian people were more or less near to the Negroes and Negritoes than to the Australians.

This fact, on the other hand, is wholly untenable when we minutely examine the mean values of the stature, the sitting height and the sitting height-stature indices of the Negroes and the Negritoes, when compared with that of the South Indian groups of people, measured by the present authors, Schmidt and Newton.

Our thanks are due to Dr. B. S. Guha, Director, Department of Anthropology, for giving us facilities to work on this problem and for his valuable guidance.

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[1] Bardeen, C. R., General relations of sitting height to stature, and of sitting height and stature to weight. *American Journal Phys. Anthrop.*, Vol. VI, 1923, pp. 355-88.

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ESTIMATION OF THE RATE OF NATURAL GROWTH OF POPULATION FOR WEST BENGAL

By A. C. Nag

(*Paper received on 12th September, 1952*)

It is very difficult, if not impossible, to obtain a reliable estimate of the rate of 'Natural Growth' of population for West Bengal from the Census figures. The Census figures disclose the combined effect of migration and natural growth. In the absence of any unusual circumstances it might be assumed that the net balance of migration remained practically constant and an estimate of natural growth might be worked out on that assumption. But for West Bengal this assumption cannot be made because 1951 figures have been greatly disturbed by migration from Pakistan. An attempt was made to isolate the displaced persons in the course of enumeration but it is difficult to say how far this has been successful. On the one hand many persons have declared themselves as displaced persons to enjoy the facilities offered by the Government, though they had been living in West Bengal for a pretty long time. On the other hand, many persons who had been living in West Bengal away from their families and who brought their families from Pakistan as a result of the partition did not declare the new arrivals as displaced persons for sentimental reasons. In addition to the migration from Pakistan there was a heavy influx from Burma also during the last intercensal period. The Census figures for 1951 cannot therefore be used with those for 1931 (not to speak of those for 1941) for estimating the rate of the natural growth of population in West Bengal. It may be remembered that in 1941 both the principal communities of undivided Bengal inflated their numbers to enjoy political privileges accruing from numerical supremacy and that 1941 census figures were discarded as unreliable.

Again, West Bengal is not likely to exhibit the same rate of growth as undivided Bengal. The Muslim population has all along been found to increase much faster than the Hindu population in India, and West Bengal is inhabited predominantly by the Hindus whereas Undivided Bengal had a higher percentage of the Muslims than the Hindus.

A modest attempt has been made in this paper to estimate the rate of natural growth of West Bengal Population by a Sample Survey. The Data for this investigation have been collected from villages, and mostly from the Hindu community because about 80 per cent of the female population of West Bengal live in villages and because the Hindus form 78·7 per cent of the West Bengal population.

The data for determining the fertility rates were obtained through personal enquiries. A small investigation was made for the purpose. The size of the sample worked out at 4,957 families. The persons seeking the information were selected at random from a list of reliable village-workers maintained by an Institution for its organization purpose, only keeping an eye that the main districts of Bengal are represented in the selected list. Each selected worker was asked to collect the following information from a few Bengalee families residing in his own village. The items of information were:

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(a) the ages of the head of the family, of his wife and of his children, and

(b) the duration of his married life.

In case he married more than once the particulars in (a) and (b) were to be recorded separately for each wife. For the living members the present age was to be recorded and for the dead members the age at death and the calendar year of death were to be recorded. The sample thus collected was not strictly random but was perhaps free from any direct bias.

An earlier attempt was made by Prof. Ghose in determining the rate of natural growth for India from a Sample Survey made by him in Cochin. He got an incredibly low value for the rate. The reason he gave in his book for the rate being so low was that the All-India Life Table 1931 did not represent the mortality conditions of the decennium 1921–1931 but of a still earlier period. The National Planning Committee (1938) also made an attempt. They used the same Life Table as Prof. Ghose and along with that Life Table they used a Japanese Fertility Table which exhibited birth-rates much too high to represent Indian conditions. It is difficult to put any practical value on the derived rate because it contains two big errors, compensatory though they may be. In this paper two Abridged Mortality Tables have been prepared from the deaths occurring in Calcutta during the Calendar year 1951 for using them with the fertility rates derived from the Sample. It would no doubt have been better if an up-to-date Life Table could be secured, based on the experience of the whole Province. In the absence of such a table, the table prepared for this investigation may be expected to represent the present-day mortality better than an out-of-date table. Again, in working out this rate (i.e. the net reproductive rate) the father's death has been given the same weight as the mother's death, because among the Hindus the reproduction usually stops whether the mother dies or the father. In Western Countries where widow-remarriage is not an uncommon practice, this is not the case. In those countries more importance is placed on mother's death than on her widowhood. This special feature of India was lost sight of in most of the studies made in this direction in India. A new technique has been devised in this paper for giving equal importance to maternal deaths and widowhood.

Determination of Fertility Rates

Reproduction starts in a girl's life on attainment of puberty or at marriage whichever is later. It terminates at manopause, death or widowhood whichever is the earliest. In deriving the following Fertility Rates, every girl has been exposed to the risk of child-bearing from age 15, irrespective of the actual age at marriage. The effect of this assumption has been to understate the fertility rates at young (i.e. marriageable) ages of the girl. As early marriages are still prevalent in villages the assumption may not introduce much error. The number of lives exposed to risk beyond age 40 being small in the sample the last age-group has been taken as '38 and over'; the age at menopause has been assumed to be 45. The rate of fertility at age x of the mother has been taken as

$$\frac{b_x}{P_x - \frac{1}{2}\, w_x - \frac{1}{2}\, \theta_x} \text{ i.e. } \frac{b_x}{E^c_x},$$

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where,

P_x = lives under observation at age x

θ_x = deaths } at age x last birthday.

W_x = withdrawals or widows } at age x last birthday.

E^c_x = years of life exposed to the risk at age x

b_x = births to mothers aged x last birthday.

The mean fertility rate for the age-group x to $x+4$ has been taken as

$$\frac{b_x+b_{x+1}+\ldots b_{x+4}}{E^c_x+E^c_{x+1}+\ldots E^c_{x+4}}.$$

The fertility rate has been derived for age-groups (and not for individual ages) to correct the errors arising from slight mis-statement of ages. Half-a-year's exposure has been given to each mother in the year of her death or in the year of her husband's death on the assumption that deaths are uniformly distributed over a year of age. Minute correction necessary for posthumous births has been ignored. The rates derived are the 'Gross Fertility Rates'. The 'Total Fertility' works out at 5·15;

TABLE 1.

Fertility Rate according to Mother's age in Villages.

Age group	Exposed to risk (in years)	Recorded births	Mean fertility rate	Fertility rate for age-group
(1)	(2)	(3)	(3) ÷ (2) = (4)	(4) × group interval = (5)
15–18	13,511	2,642	·1955	·5865
18–23	15,884	4,272	·2689	1·3445
23–28	9,122	2,179	·2389	1·1945
28–33	4,242	789	·1860	·9300
33–38	1,847	204	·1104	·5520
38–45	601	47	·0782	·5474
	45,207	10,133		5·1549

The Fertility Table is then graduated by a second-degree parabola—

$$Y = \cdot 2698 - \cdot 00372x - \cdot 00045x^2,$$

where,

Y = Gross Fertility Rate.

x = Age of the mother last birthday minus 20.

The graduated values are shown in Table 2 from age 20 to age 40. As the fertility rates for the youngest age-group has been derived on some assumption, the graduated curve has not been extended over those ages. The graduation appears to be satisfactory when group-rates are compared.

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TABLE 2.

Age last birthday	Fertility rate*	Age last birthday	Fertility rate*
20	·2698	30	·1870
21	·2656	31	·1737
22	·2605	32	·1595
23	·2545	33	·1444
24	·2476	34	·1283
25	·2398	35	·1114
26	·2311	36	·0935
27	·2214	37	·0748
28	·2109	38	·0748
29	·1994	39	·0748
		40	·0748

* The value of 'Y' was not made to fall below ·075.

SUITABILITY OF APPLYING THE SAMPLE FERTILITY RATES TO THE POPULATION

The total fertility figure derived from this sample has been found to be 5·15. The corresponding figure derived from the Y sample for Undivided Bengal worked out at 5·65. Knowing as we do that the Muslims are more prolific than the Hindus, the total fertility figure for the Hindus must be less than 5·65. The sample figure thus appears to be reasonable, that is, a Bengali Hindu woman may be expected to give birth to a little over five children on an average, if she remains exposed to the risk of child-bearing over the 'whole' of the reproductive period. But in actual practice the period of reproduction is cut short by widowhood or death of the mother. The total fertility figure has no practical value unless it is adjusted for this shortage of exposure. We shall discuss about these adjustments later and attempt to derive an index for measuring the prospect of population growth in West Bengal. Before proceeding to work for these adjustments it was thought desirable to examine the suitability of applying the specific fertility rates derived from the sample to the actual population of West Bengal, because the sample was rather small in size for population studies. The overall birth-rate for Bengal has been computed below by applying the sample Fertility rates to the actual distribution of population and this rate has been compared with the corresponding figure published by the Government. For computing the above rate it is necessary to know the age-distribution of the female population as also the proportion of spinsters and widows at different ages. During the tabulation of the 1951 census figures the age-distribution of the female population by Marital status has been obtained for a 10 per cent sample for Calcutta, Hooghly and West Bengal. The following table has been prepared from those 10 per cent samples to exhibit the age-distribution in percentage. Table 3 below reveals that the age-distribution of the female population at reproductive ages (i.e. 15–44) is practically the same in Hooghly as in the whole province. In Calcutta, however, there is a higher proportion of females at reproductive ages, the percentage being 49·3 as against 47·7 in West Bengal.

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TABLE 3.

Age last birthday.	West Bengal*		Calcutta*		Hooghly	
	Recorded No.	p.c.	Recorded No.	p.c.	Recorded No.	p.c.
0 ..	28,673	2·75	2,565	3·48	1,782	2·53
1– 4 ..	1,04,348	10·02	7,355	9·97	6,992	9·91
5–14 ..	2,52,711	24·25	17,015	23·05	17,349	24·59
15–24 ..	2,13,634	20·51	15,834	21·45	14,517	20·57
25–34 ..	1,67,922	16·12	12,318	16·69	11,018	15·61
35–44 ..	1,15,026	11·04	8,252	11·18	7,823	11·09
45 & Over ..	1,59,520	15·31	10,465	14·18	11,081	15·70
Total ..	10,41,834	100·00	73,804	100·00	70,562	100·00

* Excluding displaced persons.

The next table (Table 4) gives the proportions of spinsters, widows, and married women separately to the female population (married, spinster and widow together) for different age-groups within the reproductive period. In this tabulation also displaced persons have been excluded from the Calcutta and West Bengal population. It appears from column 5 (of Table 4) that the proportion of unmarried women is much higher in Calcutta during the age-period 15–24; this is due to the marriages occurring at much higher ages in Calcutta than in other parts of Bengal.

TABLE 4.

Distribution of female population at different ages by marital status from the 10 per cent sample of the 1951 census.

Age last birthday	West Bengal			Calcutta			Hooghly		
	Spinsters	Widows	Married	Spinsters	Widows	Married	Spinsters	Widows	Married
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
15–24	13·4%	4·3%	82·3%	28·7%	2·7%	68·6%	16·3%	3·5%	80·2%
25–34	2·1	13·4	84·5	6·1	11·0	82·9	2·4	16·0	81·6
35–44	0·6	30·2	69·2	2·6	30·4	67·0	1·1	33·5	65·4

The crude birth-rate per 1,000 female population is then obtained for West Bengal villages, by applying fertility rates of the Village sample to the actual distribution of the population of West Bengal as a whole. The villagers form 75 per cent of the total population of West Bengal according to the 1951 census figures. It has been shown later in this paper that a high percentage of the male population in towns keep their wives in villages for economic difficulties and the shortage of accommodation in towns. The rural female population thus forms over 80 per cent, say, of the total female population of West Bengal. The distribution of the rural population by age and marital status is not available now; the distribution of the West Bengal population which is over 80 per cent rural, has therefore been used.

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The computation of the crude birth-rate is shown in Table 5. The figures of column 2 of Table 5 have been obtained from those of column 3 of Table 3 which shows that in a population of 1,000 females there are 205 females at ages 15–24, 160 females at ages 25–34 and 110 females at ages 35–44. The figures of column 3 of Table 5 have been obtained from those of column 4 of Table 4. The figures for quinquennial age-groups have been determined tentatively from the figures of decennial age-groups, simply keeping an eye on the trend because we are concerned simply with level of the derived rate and not with its absolute value. The mean-fertility rates, shown in column 5 have been obtained from Table 2 for all age-groups excepting the first and the last. The two extreme values have been inserted more or less arbitrarily; it may be remembered that these rates were derived on some assumptions.

TABLE 5.

Birth-rate per 1,000 female population in West Bengal on Rural Fertility Basis.

Age last birthday	Females	Proportion married	Married females	Fertility rates	No. of births
(1)	(2)	(3)	(2) × (3) = (4)	(5)	(4) × (5) = (6)
15–19 ..	110	·82	90	·225	20·3
20–24 ..	95	·83	79	·260	20·5
25–29 ..	85	·84	71	·220	15·6
30–34 ..	75	·85	64	·159	10·2
35–39 ..	60	·75	45	·086	3·9
40–44 ..	50	·65	33	·075	2·5
	475				73·0

The birth-rate works out at 73·0 per thousand female population. According to 1951 census figures there are 11·46 million females in West Bengal in a total population of 24·80 million persons. The birth-rate per thousand population thus works out at 33·7 $\left(= 73\cdot0 \times \frac{11\cdot46}{24\cdot80}\right)$. It is of no use to compare this rate with the figure of registered births because a fair percentage of births escape registration. In Bengal where infantile mortality is very high this omission is likely to be frequent. The Public Health Directorate of West Bengal made a pilot survey in 1949 covering 20,911 families to estimate the degree of omission. The birth-rate per thousand population was found to be 32·7 for Hindu villagers in that survey. The sample figure thus stands at the same level as that of the Pilot Survey. The fertility rates derived from the sample may therefore be used with the actual population in determining the index of population growth.

DETERMINATION OF AN INDEX FOR POPULATION GROWTH.

We now attempt to obtain an index of population growth from these rates, adjusting them for mortality. The mortality rates have been derived from the 1951 census population and the 1951 death figures in Calcutta. The reason for selecting Calcutta is that the death-registration is more or less complete in Calcutta; it is not so in any other place in Bengal. In a normal year the mortality of Calcutta may be assumed to represent

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the mortality of the whole province. There are no doubt extra hazards of big cities but against them may be set off the extra precautions, the better public health services and the more efficient medical aid. The original registers of the Calcutta Corporation were consulted to obtain these death-records. It is always safe to use the death-records of more than one year in deriving mortality rates but as 1950 was an epidemic year in Calcutta the death-records of 1950 could not be used. The method used in deriving the mortality rates is given below together with its rationale:—

Let P_{x+t} be lives attaining the precise age '$x+t$' during the year.

$'P_x^{\,r}$ be lives aged 'x' last birthday at precise moment of time 'r' from the beginning of the year.

E_x^c be the years of life exposed to risk between exact age 'x' and exact age '$x+1$', i.e. in effect the mean number of lives under observation between ages 'x' and '$x+1$' during the calendar year.

$P_{x+t}^r\,dr$ be the number of lives attaining the precise age '$x+t$' at the precise moment of time 'r' from the beginning of the calendar year.

θ_x be the deaths recorded during the year at age x last birthday.

m_x be Central rate of mortality at exact age x

Then

$$E_x^c = \int_0^1 P_{x+t}\,dt = \int_0^1\int_0^1 P_{x+t}^r\,dr\,dt = \int_0^1\int_0^1 P_{x+t}^r\,dt\,dr$$

$$= \int_0^1 {'P_x^{\,r}}\,dr \quad \left(\text{since} \int_0^1 P_{x+t}^r\,dt = {'P_x^{\,r}}\right)$$

And

$$m_x = \frac{\theta_x}{E_x^c} = \frac{\theta_x}{\int_0^1 {'P_x^{\,r}}\,dr}.$$

In the case of a population where there are no violent fluctuations in the course of the calendar year we can take:—

$$\int_0^1 P_x^{\,r}\,dr = {'P_x^{\frac{1}{2}}}$$

$\therefore m_x = \dfrac{\theta_x}{'P_x^{\frac{1}{2}}}$ where $'P_x^{\frac{1}{2}}$ = lives aged x last birthday in the middle of the year.

The values of m_x cannot be determined unless the population and the deaths are recorded for individual ages. But the population are given in age-groups in the Census Report, the grouping being made to correct the biassed errors arising in the statement of age. The values of ${}_nm_x$ have therefore been calculated instead of m_x, ${}_nm_x$ being equal to

$$\frac{\theta_x+\theta_{x+1}+\ldots\theta_{x+n-1}}{'P_x^{\frac{1}{2}}+'P_{x+1}^{\frac{1}{2}}+\ldots{'P_{x+n-1}^{\frac{1}{2}}}}$$

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From these values of $_{n}m_{x}$ the values of $|_{n}Q_{x}$ have been derived by using the equations suggested by Reed and Merell in the *American Journal of Hygiene* (Vol. 30, pp. 33–62); $|_{n}Q_{x}$ represents the probability of a life aged exactly x dying within n years, i.e. before attaining the age '$x+n$'. Raymond Pearl in his book 'Medical Biometry and Statistics' has given tables from which the values of $|_{n}Q_{x}$ may be read corresponding to $_{n}m_{x}$. These tables have been used here; in some cases (for infantile ages) it has become necessary to go beyond the table and the values have been obtained by extrapolation. In calculating q_0 from m_0, the equation used includes implicitly correction for under-enumeration of the population within this age-group. As death rate is high in India for the first year of life and as the assumption made regarding under-enumeration may be different in India, the values of q_0 has been modified from practical experience.

Now for determining the values of $_{n}m_{x}$ we require the values of 'P_{x}' (i.e. population in the middle of the year). But the 1951 census was taken on 1st April. The population figures therefore need adjustment; this adjustment would have been possible if the 1941 census figures were correct. But we know that the 1941 census figures were greatly disturbed on account of political considerations, particularly in Calcutta. This adjustment not being feasible from 1941 and 1951 census figures, we could use death records from 1st October, 1950 to 30th September, 1951 but then 1950 was an epidemic year. No adjustment could therefore be made. Moreover, the age-distribution of the Calcutta population is not available at the moment. The total female population of Calcutta has therefore been distributed on the basis of the 10 per cent sample. The age-distribution of the displaced persons is, however, available. As the actual age-distribution of the total population of Calcutta could not be used in determining the values of $_{n}m_{x}$, small errors will no doubt appear but such small errors would not materially affect the results. Mortality rates do not remain stationary; they always fluctuate from year to year. All that we aim at is to determine the level of mortality.

Table 6 below gives the age-distribution of the female population in Calcutta separately for permanent residents and displaced persons.

TABLE 6.

Age-Distribution of (a) Permanent and (b) Displaced female population in Calcutta in 1951.

Age last birthday	Permanent		Displaced		Total Number
	Number	p.c.	Number	p.c.	
(1)	(2)	(3)	(4)	(5)	(2)+(4)=(6)
0 ..	25,248	3·48	577	0·29	25,825
1– 4 ..	72,398	9·97	14,846	7·46	87,244
5–14 ..	1,67,485	23·05	58,849	29·57	2,26,334
15–24 ..	1,55,860	21·45	47,588	23·92	2,03,448
25–34 ..	1,2[illegible]	16·69	28,698	14·12	1,49,349
35–44 ..	81,227	11·18	19,344	9·72	1,00,571
45 & over ..	1,03,011	14·18	29,684	14·92	1,32,695
Total ..	7,26,480	100·00	1,98,986	100·00	9,25,466

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This table disclosed an alarming feature. It shows that the proportions living at infantile ages are much less among the displaced persons than among the permanent residents in Calcutta. There are 35 girls below one year of age and 100 girls between one and four years of age per thousand female population in Calcutta among the permanent residents whereas the corresponding numbers are 3 and 75 respectively among the displaced persons. This disparity is the result of low birth-rate and high death-rate among the displaced persons. The huddling up of displaced families in one or two roomed cottages, the unaccustomed low standard of living and unhealthy environments are mainly responsible for this low birth-rate and high death-rate. The disparity mentioned among the female children is also present among the male children. If the conditions do not improve appreciably the displaced population will gradually vanish.

The following table (Table 7) has been prepared for the female population of Calcutta to exhibit the values of ${}_nm_x$ and $|_nQ_x$. Subtracting the values of $|_nQ_x$ from unity, we get the values of ${}_np_x$; the survival factor ${}_np_x$ gives the probability of a life aged exactly x surviving to the exact age '$x+n$'. The probability of dying in the first year of life is found to be 166 per mille. In the Pilot Survey conducted by the Public Health Directorate, referred to above, the corresponding probability was found to be 166 per mille for males and 154 per mille for females. In this study we shall fix this probability at the average figure 160 per mille for females.

TABLE 7.

Mortality among female population in Calcutta during 1951.

Age last birthday	Census population	Recorded deaths	${}_nm_x$	$\|_nQ_x$	${}_np_x$
(1)	(2)	(3)	(4)	(5)	1−(5) = (6)
0 ..	25,825	5,628	·218	·166	·834
1– 4 ..	87,244	3,887	·0445	·146	·854
5–14 ..	2,26,334	1,825	·0081	·078	·922
15–24 ..	2,03,448	2,253	·0111	·106	·894
25–34 ..	1,49,349	1,867	·0125	·119	·881
35–44 ..	1,00,571	1,351	·0134	·127	·873

Using the survivorship factors of Table 7 the number of girls surviving to age 15 (i.e. the earliest age for motherhood) out of 1,000 female births is first determined. Out of 1,000 female births, 160 would die within the year and 840 would survive one year. Out of 840 girls reaching the age one, 717 ($=840\times\cdot854$) would survive to age 5. Out of 717 girls at age 5, 661 ($=717\times\cdot922$) would reach the age 15. It is now assumed that every one of these 661 girls get married at age 15; because the fertility rate for the age-group 15–18 has been obtained on similar assumption. Now, among Bengali Hindus the death of the husband is as bad from the reproductive point of view as the death of the wife because very few widows remarry. Each of those 661 girls remains exposed to the risk of child-bearing till menopause (i.e. till age 45) unless she dies or becomes a widow earlier. The survival of the husband should therefore be studied in conjunction with that

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of the wife. The survivorship factors are given in Table 7 for females. The corresponding factors for males have been determined on similar lines and shown in column 7 of Table 8. The values of ${}_nm_x$ are found to be abnormally low for males when compared with those for females, even after making due allowance for extra mortality resulting from child-birth. This is due to the presence of a floating male population in Calcutta. These males live away from their families and whenever there is any serious illness they go to their families. Their deaths are usually recorded outside Calcutta. The inclusion of this floating population in the living-group and the exclusion of their deaths from the dead-group are responsible for these abnormally low rates. The volume of this floating population has been determined in the following way. In West Bengal there are 11·46 million females and 13·34 million males. In Calcutta there are 7·27 lacs of females. Using the over-all sex-ratio of West Bengal the male population of Calcutta works out at 8·46 $\left(=7{\cdot}27\times\frac{13{\cdot}34}{11{\cdot}46}\right)$ lacs; but there are actually 13·88 lacs of males in Calcutta, excluding displaced persons. The floating male population is thus as big as 39 per cent $\left(=\frac{13{\cdot}88-8{\cdot}46}{13{\cdot}88}\times100\right)$ of the total male population in Calcutta. Assuming that deaths of one-third (i.e. $33\frac{1}{3}$ per cent) of the total male population escape registration in Calcutta, fresh values of ${}_nm_x$ have been obtained by multiplying the original value by 1·5 $\left(=\frac{100}{66\frac{2}{3}}\right)$. From these revised values of ${}_nm_x$, the value of $|{}_nQ_x$ and ${}_np_x$ have been obtained. It must be mentioned here that these revised values of ${}_nm_x$ stood at the same level with those of the Pilot Survey.

TABLE 8.

Mortality among male population in Calcutta in 1951.

Age last birthday	Census population	Recorded deaths	${}_nm_x$	$1{\cdot}5\times{}_nm_x$	$\vert{}_nQ_x$	${}_np_x$
(1)	(2)	(3)	(3)÷(2) = (4)	1·5×(4) = (5)	(6)	1−(6) = (7)
15–24 ..	3,99,014	2,029	·0051	·0076	·074	·926
25–34 ..	3,89,206	2,213	·0057	·0086	·083	·917
35–44 ..	2,46,343	2,125	·0086	·0129	·122	·878
45–54 ..	1,40,975	2,216	·0157	·0236	·204	·796

It is now necessary to determine the usual age-difference of the Bengalee couples. The sample is divided into two parts according to the duration of married life. Marriages occurring in the last decade (i.e. recent marriages) have been separated from the earlier (i.e. old) marriages. Those cases where the duration since marriage was not recorded have been treated as 'Old Marriages', because the omission is more usual in old marriages. Table 9 below shows that the distribution of marriages by Age-difference has not changed with time and that the average age-difference is near about 7 years.

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TABLE 9.

Distribution of marriages by age-difference of the couple in the village sample.

Age difference in years	Recent		Old		Total	
	No. of marriages	p.c.	No. of marriages	p.c.	No. of marriages	p.c.
0– 4 ..	443	17·3	425	17·7	868	17·5
5– 9 ..	1,559	60·8	1,374	57·4	2,933	59·2
10–14 ..	491	19·2	514	21·5	1,005	20·3
15 & over ..	70	2·7	81	3·4	151	3·0
Total ..	2,563	100·0	2,394	100·0	4,957	100·0

Now let ${}_np^f_x$ and ${}_np^m_x$ represent the probability of a female and a male life respectively of exact age x surviving n years. The probability of a wife aged 15 years surviving 10 years along with her husband aged 22 years is given by ${}_{10}p^f_{15} \times {}_{10}p^m_{22}$. The value of ${}_{10}p^m_{22}$ is derived from the values of ${}_{10}p^m_{15}$ and ${}_{10}p^m_{25}$ (given in column 7 of Table 8) by simple interpolation; it works out at ·920 ($= \cdot 926 - \cdot 7 \times \cdot 009$). Similarly the values of ${}_{10}p^m_{32}$ and ${}_{10}p^m_{42}$ work out at ·890 and ·821 respectively.

We next proceed to find out the number of women who would survive to age 25, 35 and 45 along with their husbands, out of 661 girls who attained the age 15. Let these numbers be denoted by $(ml)_{25}$, $(ml)_{35}$ and $(ml)_{45}$.

$$\begin{aligned}
(ml)_{25} &= 661 \times {}_{10}p^f_{15} \times {}_{10}p^m_{22} \\
&= 661 \times \cdot 894 \times \cdot 920 \\
&= 545 \\
(ml)_{35} &= 545 \times {}_{10}p^f_{25} \times {}_{10}p^m_{32} \\
&= 545 \times \cdot 881 \times \cdot 890 \\
&= 427 \\
(ml)_{45} &= 427 \times {}_{10}p^f_{35} \times {}_{10}p^m_{42} \\
&= 427 \times \cdot 873 \times \cdot 821 \\
&= 306
\end{aligned}$$

The values of $(ml)_{20}$, $(ml)_{30}$ and $(ml)_{40}$ are then obtained from the above values by simple interpolation. The following table (Table 10) has then been prepared to give the total fertility figure for the sample under investigation after making due allowance for mother's death and widowhood.

The values of $(ml)_{15}$ and $(ml)_{45}$ have been assumed to denote the mean survivors for the two extreme groups. The errors introduced by the assumption are not material; moreover, they act in opposite directions. For this sample, the age-groups '38–43' and '43 and over' have been amalgamated in deriving the fertility rate (·547). The 'mean survivor figure' that should be used in conjunction with this rate must be between 367 and 306; this figure has been assumed to be 340. The figures in Table 10 show that if 100 girls are born now and they all marry at age 15, they will throughout their life-time give birth to 273 (say) children, if the fertility and the mortality remain at the present level.

In population dynamics we are more concerned with female births than with total births, because, each female born is a potential mother who will directly contribute towards population growth. So our interest is to know how many of the 273 children mentioned above are likely to be of

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TABLE 10.

Total Fertility after making due allowance for mother's death and widowhood.

Age	Mean survivor	Fertility Rate Gross	Fertility Rate Net
(1)	(2)	(3)	(2) × (3) = (4)
Below 18 ..	·661	·587	·388
18–23 ..	·604	1·345	·812
23–28 ..	·545	1·195	·651
28–33 ..	·486	·930	·452
33–38 ..	·427	·552	·236
38 & over ..	·340	·547	·186
Net reproductive rate ..		5·156	2·725 1·332

female sex. This point has been studied from the records of two Maternity Hospitals in Calcutta, Sishumangal Pratisthan and Baldeodas Maternity Homes. In both these Homes over 85 per cent of the cases are Bengali Hindus. There were 35,149 births, during the years 1948 to 1951 in these two Hospitals of which 17,058 were girls. Sex-ratio at birth, i.e. the proportion of female to total births, works out at ·485. Though this ratio has been derived from hospital data, it does not appear unsuitable for being used for the general Hindu population because the usefulness of a maternity hospital is now well-recognized and the people are in the habit of sending the expectant mothers to the hospital, no matter whether the case is normal or difficult. Of the 273 births mentioned above 133 (= 273× ·485) are likely to be of female sex. This means that 100 girls now born will give birth to 133 girls during their life-time if none of them remains unmarried after age 15 and the fertility as also the mortality do not change with time.

In another paper I have shown that in villages the reproduction starts early and ends early whereas in towns it starts late and ends late too, the result being that the total fertility figure is more or less the same among the general population, whether villagers or town dwellers. A slight shifting of the average age at marriage on the high side would not reduce the net reproductive rate (i.e. 1·33) obtained above. Assuming that the reproduction continues for 25 years (on an average) in a girl's life, the decennial increase in population works at 12 per cent. The overall rate of increase has been found to be 12·5 per cent for India during 1941–51. Now unless the idea of family-planning becomes popular with our general population the birth-rate will not decline; the death-rate, however, has improved and will further improve. The result would be further increase in the rate of growth of population in the future.

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A SHORT NOTE ON THE PROPORTION OF THE UPPER AND LOWER EXTREMITIES OF THE BODY OF THE HILL TRIBES OF TRAVANCORE AND COCHIN

By B. K. CHATTERJI *and* G. D. KUMAR

(*Paper received on 9th September, 1952*)

(Communicated by Dr. W. G. Griffiths)

The upper and the lower extremities of the body of the different hill tribes, viz., 140 Kannikars, 125 Uralis, 37 Malapantarams, 19 Kuravans, 31 Muthuvans and 47 Paliyans, were measured in connection with our somatometric studies among them during the period of 1948-49.

In taking the somatometric measurements, only the adult male members of the different hill tribes were measured and the instruments manufactured by Messrs. P. Hermann, Rickenbach & Son, Zurich, were used. The measurements are given in millimetres and the different indices of body proportions propounded by Martin and others [1] were followed.

TABLE I

Table I shows the mean values of the lengths of the forearm, upper arm, lower leg with their variations and also Tibio radiale and Brachial indices of the hill tribes of Travancore.

	Mean length of Forearm. (mm.)	Range of Variation.	Mean length of Upper Arm. (mm.)	Range of Variation.	Mean length of Lower Leg. (mm.)	Range of Variation.	Tibio radiale Index.	Brachial Index.
Kannikar ..	226·19	315–157	305·35	357–205	371·97	480–307	61·29	75·06
Urali ..	230·60	289–185	314·56	425–237	379·18	459–237	61·30	75·56
Malapantaram	236·68	333–150	315·68	413–272	378·19	428–254	62·48	75·31
Kuravan ..	234·05	263–207	308·79	354–224	382·10	420–339	61·56	73·50
Muthuvan ..	229·48	261–200	315·32	338–286	382·83	432–338	60·02	72·82
Paliyan ..	231·04	266–202	319·97	414–244	385·85	455–335	59·40	72·55

N.B.—Brachial Index $= \frac{\text{Length of forearm}}{\text{Length of upper arm}} \times 100$

Tibio radiale Index $= \frac{\text{Length of forearm}}{\text{Length of lower leg}} \times 100$

It would appear from Table I that very little difference was noted in the mean values of the upper arm among the different tribes, except the Paliyans, but the range of variation was considerable. The mean values of the forearm of the different tribes show a very little difference but the range of variation was found to be considerable which indicates the

[1] Martin, R.—Lehrbuch der Anthropologie, 1928, Vol. I, pp. 182, 173.
Wilder, H.—Laboratory Manual of Anthropometry, pp. 165-66.

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presence of admixture. It would also appear from the table that very little difference was observed in the mean values of the lower leg of the various tribes. The range of variation was also considerably high in this character. In the Brachial and Tibio radiale indices, it may be remarked that very little difference was observed among different tribes.

It is interesting to note that though the mean values of the different characters approach very close to each other, the range of variation in different characters is considerable. Such high variations indicate the possibility of luxurization in different degrees amongst certain tribes.

TABLE II

Table II shows the averages of the Tibio radiale and Brachial indices of the different tribes and peoples of India and abroad.

Group.	Tibio radiale Index.	Brachial Index.
Kannikar	61·29	75·06
Urali	61·30	75·56
Malapantaram ..	62·48	75·31
Kuravan	61·56	73·50
Muthuvan	60·02	72·82
Paliyan	59·40	72·55
Andamanese	67·8	..
Aino	67·7	77·4
Australier	64·9	..
Javanen	..	80·0
Senoi	..	76·0
Tamilen	..	78·0
Neger	65·4	..
Kongo Neger	..	93·4
Pariser	63·5	75·4
Chinesen V. Setschuan ..	..	86·0
Feuerlander	70·9	80·6

From Table II,[1] it appears that considerable difference is in existence when the mean values of the Tibio radiale and Brachial indices of the hill tribes of Travancore, viz., the Kannikars, the Uralis, the Malapantarams, the Kuravans, the Paliyans and the Muthuvans, are compared with the Andamanese, the Kongo Neger, the Australians and the Chinese. The existence of such difference reveals that it is probably due to the presence of different racial traits.

Our thanks are due to Dr. B. S. Guha, Director, Department of Anthropology, for giving us facilities to work on this problem and for his valuable guidance.

[1] Martin R.—Lehrbuch der Anthropologie, 1928, Vol. I, pp. 394, 429.

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ON A COLLECTION OF FISH FROM RAJGIR, PATNA DISTRICT, BIHAR

By H. L. Sarkar

(*Paper received on 11th September, 1952*)

(Communicated through Dr. J. L. Bhaduri, D.Sc., F.N.I., F.A.S., F.Z.S.I.)

A small representative collection of fish was made by the writer from different places of two small streams, the Banganga and the Saraswati, at Rajgir during his short visits at different times of the year 1948. The fishes were collected by drag net, made of cloth fixed on a triangular bamboo frame, cast net, rod and line and by hands,[1] by the local people.

Rajgir, a very old place of historical importance, is situated to the south-west of the Bihar Shariff Sub-Division in the district of Patna. The old Rajgir is situated in the valley surrounded by a group of five hills, the Bipulagiri, the Baivergiri, the Ratnagiri, the Udayagiri and the Sonagiri. The two small streams, the Saraswati and the Banganga, flow through the valley close to the foot of the hills.

The present Rajgir, which is known as New Rajgir, has been developed as a health resort on account of the presence of several hot springs and is situated to the north of the old town, outside the valley. The drainage water of this area flows into a channel, which passes between the two hills, the Baivergiri and the Bipulagiri, and finally bifurcates to form the Saraswati and the Banganga. The Saraswati runs very close to the foot of the Baivergiri and receives the drainage waters of the hot springs, originating from the Baivergiri. The Banganga, on the other hand, takes a course through the valley near the foot of the Ratnagiri and the Udayagiri. Both the streams finally come out from the valley and fall into the river Panchana, a tributary of the Ganges.

The streams Saraswati and Banganga are very shallow and have only restricted flow. During the dry season, they dry up considerably, specially the Banganga. The Saraswati gets a constant supply of water due to the drainage from the springs. Pools of different sizes and depth are, however, found all along the beds of the streams even in summer. Collections were also made from these pools.

The bed of the Saraswati is mostly sandy with stones and pebbles, while that of the Banganga is sandy, mixed with mud and clay. Vegetation is scanty, only algal growth being observed in the pools and channels. The water is clear during greater part of the year, except in the rainy season, when it is somewhat muddy.

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[1] Gudger, E. W.—*J. Zoo. Soc. India*, III, 2, pp. 360-61 (1951).

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The collection under report comprises specimens belonging to the following 13 species:—

Family CYPRINIDAE.
Sub-Fam. Abramidinae.
1. *Chela bacaila* Ham.
Sub-Fam. Rasborinae.
2. *Brachydanio rerio* (Ham.).
3. *Esomus danricus* (Ham.).
Sub-Fam. Cyprininae.
4. *Puntius sophore* Ham.
5. *Puntius ticto* Ham.
Family COBITIDAE.
6. *Lepidocephalus guntea* (Ham.).
Family BAGRIDAE.
7. *Mystus vittatus* (Bloch.).
Family GOBIIDAE.
8. *Glossogobius giuris* (Ham.).
Family CHANNIDAE.
9. *Channa gachua* (Ham.).
10 *Channa punctatus* (Bloch.).
Family ANABANTIDAE.
11. *Colisa fasciatus* (Bl. & Schn.).
Family MASTACEMBELIDAE.
12. *Mastacembelus pancalus* (Ham.).
13. *Rhynchobdella aculeata* (Bloch.).

Majority of the species are fairly well known and widely distributed and do not call for any special remarks. Some remarks are, however, made on the following three species:—

Esomus danricus (Hamilton).

1938. *Esomus danricus*, Hora, *Rec. Ind. Mus.*, XL, p. 173.

Fifteen specimens were collected from the Saraswati near the foot of the Baivergiri during different times of the year.

E. danricus is one of the most widely distributed Indian species and is very common in Assam, Bengal, Bihar, Orissa, Central Province, the Punjab and South India. In South India *Esomus barbatus* (Jerdon) is more common.

Day[1] reports the occurrence of *E. danricus* from hot stream with a temperature of 112°F. at Pooree (Puri) and also from hot stream at Cannia (Kanniya) in Ceylon.

According to Hora and Mukerji,[2] *Esomus thermoicos*, which was originally described from the hot springs at Kanniya, is the commonest species of Ceylon. It is reported by them that *Esomus danricus* is not found in hot springs at Kanniya even within the radius of 300 yards of the springs.

The specimens under report, though they were not directly collected from the hot spring, with a temperature of 106° to 110°F., were collected within 100 yards from the point, where hot water drains into the Saraswati. At this point the temperature of the water varies from 88° to 100°F.

These observations show that some species of the genus *Esomus* can live in hot streams or near about the streams.

Puntius ticto (Hamilton).

1939. *Barbus* (*Puntius*) *ticto*, Hora, Misra and Malik, *Rec. Ind. Mus.*, XLI, pp. 263–279.

Fourteen specimens were collected from the Banganga and the Saraswati streams during different parts of the year.

Hora, Malik and Misra (1939, *loc. cit.*) have recorded *Puntius ticto* from different places in Bihar. They have observed some variations in the characters in the specimens collected from different localities. In all the

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[1] Day, F.—*Fish. India*, p. 583 (1878).
[2] Hora, S. L. and Mukerji, D. D.—*Rec. Ind. Mus.*, XXX, pp. 44–46 (1928).

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specimens under report, the lateral line is complete. There are 23-24 scales along the lateral line. The anterior spot is absent, the posterior one is on the 20th to 22nd scales. Number of predorsal scales is 9. In these respects the specimens under report almost agree with those from Chota Nagpur by Hora *et al.*

Rhynchobdella aculeata (Bloch.).

1940. *Rhynchobdella aculeata*, Hora, *Rec. Ind. Mus.*, XLII, p. 371.

Two well-developed specimens were collected from the Saraswati stream, near the foot of the Baivergiri.

In both the specimens only three black ocelli were present on the right and four on the left side of the dorsal fin.

Day [1] gives 'Brackish waters within tidal influence' as the habitat, while Hora [2] observed that *R. aculeata* is found in abundance in marshy areas, far above the tidal influence, in the districts of Bihar. Shaw and Shebbeare [3] also recorded the species from the muddy streams of Duars. Later, Hora (1940, *loc. cit.*) recorded this species also from the Raipur district which 'shows that the fresh water is no bar to its distribution and it is likely that the fish will be found to be more widely distributed in the inland waters of India'.

It may be noted that the specimens collected from both the places, *i.e.*, Raipur district and Rajgir, though they were taken from places far above the tidal influence, were not from marshy areas. They were collected from the seasonal streams, the beds of which are sandy or of sand mixed with mud.

Acknowledgements

I am indebted to Dr. S. L. Hora, Director, Zoological Survey of India, for his valuable suggestions and criticism. Thanks are due to Dr. M. L. Bhatia, Head of the Zoology Department, University of Delhi, for facilities and encouragement.

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1 Day, F.—*Fish. India*, p. 338 (1878).

2 Hora, S. L.—*Trans. Nat. Inst. Sci. India*, I, p. 8 (1935).

3 Shaw, G. E. and Shebbeare, E. O.—*Journ. Roy. As. Soc. Bengal, Science*, III, p. 127 (1937).

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SYNADENIUM GRANTII HOOK. F. (FAM.: *EUPHORBIACEAE*)—ITS OCCURRENCE IN BENGAL AND SOME MORPHOLOGICAL AND ANATOMICAL OBSERVATIONS

By Jatindra Nath Mitra, *Department of Botany, Presidency College, Calcutta and* Robindra Mohon Datta, *Jute Agricultural Research Institute, Barrackpore, 24-Parganas*

(*Paper received on 27th December, 1952*)

Synadenium Grantii Hook. f. is an Euphorbiaceous shrub with round terete stem and thick alternate shortly petioled obovate-oblong leaves (Text-fig. 1). It is found growing wildly throughout the length and breadth of Bengal and the people have been found to use it as a good hedge plant. Though the plant has been growing in Bengal for the last 60 years according to our information, it has escaped the attention of eminent systematists like Sir J. D. Hooker (1885) and Sir David Prain (1903). Brown, Hutchinson and Prain (1911–13), Pax and Engler (1921), Pax and Hoffman (in Engler, 1931), and Jacobsen (1946) have found it and recorded that it is a native of tropical Africa. There is no record available how it came to this province, who had first introduced it and for what

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1.

Text-fig. 1. Adult twig. ½ Nat. size.

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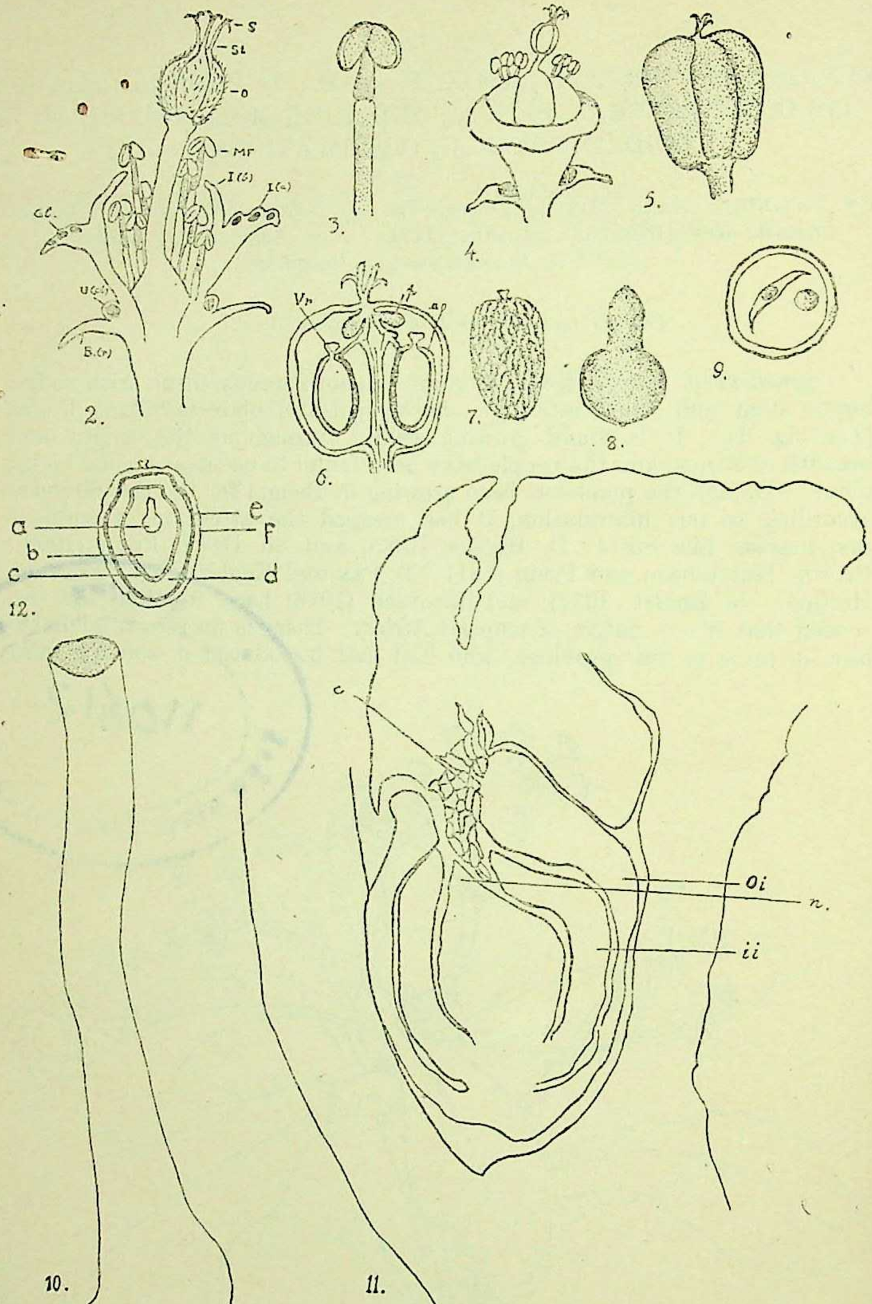

TEXT-FIGS. 2–12.

2. Sectional view of a single cyathium showing the positions of flowers and involucre (bracteoles removed). ×13. *s*—stigma; *st*—style; *o*—ovary; *mf*—monandrous flower; *I*(*a*)—outer portion of involucre; *I*(*b*)—Inner portion of involucre; *Gl*—gland; *U*(*cb*)—undeveloped cyathium bud; *B*(*r*)—Scaly bract.

(*Continued at foot of next page.*)

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purpose, and the like. As the plant is very hardy and even a cut portion of the twig has been seen to root easily in a slightly moist condition, it has actually spread out very easily throughout the four corners of this province not only by its dispersal of seeds but also by vegetative means.

Morphology

Milky latex occurs copiously in all the aerial parts. Unisexual flowers are found in dichasial cyathia which appear saucer-shaped or bell-shaped; the inner membranous involucre surrounding the florets of the cyathium is 5-lobed, thin, adnate to the outer saucer-shaped fleshy expansion of involucre bearing glands. Both are connate and adnate to each other, ultimately forming the cupular investment. Involucral bracts are thus 2-seriate (Text-figs. 2 & 4). Cyathia occur at the tip of shorter branches or at the axil of bifurcation of branches with a pair of free persistent bracts at the base of each involucre. These bracts bear undeveloped glandular branch buds at the axils (Text-figs. 2 & 14). The glandular buds represent the undeveloped cyathia which become evident when sections of different such stages are examined.

The so-called 'flower' or cyathium is really a condensed inflorescence suppressed in a gamophyllous involucre of five bracts. This, cymose in nature, is composed of a main or central axis and five spirally arranged sub-whorled axillary branches, each of which is subtended by a bract. The cyme terminates in a naked pistillate flower possessing an abortive rudimentary perianth in the form of a slight scale below the ovary (Text-fig. 2). Each axillary shoot is, at the base, in the form of a dichasium, the terminal flower of which is represented by a single stamen. Each of the lateral shoots of the dichasium develops a monochasium of monandrous flowers, each being subtended by a bracteole. A slight ring-like indentation below the anther represents the position of an abortive perianth (Text-fig. 3).

The earliest investigators on the inflorescence of the family *Euphorbiaceae* held three different sets of views. Tournefort (1700), Linnaeus (1753), Payer (1857) and Baillon (1858) concluded that the true status was that of a single hermaphrodite flower. Lamarck (1786) considered cyathium as an assemblage of smaller flowers. The bracts, according to him, form a common calyx; the bracteoles between the groups, the calyx proper of each staminate flower. The most generally accepted view was first put forward by Robert Brown (1818) that within the involucre there is a complicated androgynous inflorescence, in which the pistillate flower is the gynoecium, and the monandrous flowers are reduced stamens forming lateral inflorescences, arising in the axes of the peripheral leaves, which

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(*Continued from foot of previous page.*)

3. A single monandrous flower showing the pedicel and articulation and a single stamen. ×15.
4. Cyathium. ×3.
5. Mature ovary. ×10.
6. Long. sec. of the ovary showing the remnants of style and stigma and *p*—placental outgrowth; *Vr*—ventral raphe; *a.o.*—anatropous pendulous ovule. ×10.
7. Mature seed showing the caruncle. ×15.
8. Embryo with superior radicle. ×40.
9. Binucleated pollen grain. ×120.
10. A single bracteole. ×75.
11. Section of an ovule showing the development of caruncle (*c*) from the outer integument; *oi*—outer integument; *ii*—inner integument; *n*—nucellar beak. ×175.
12. Diagrammatic section of the seed showing *f*—caruncle; *c*—testa; *t*—perisperm; *c*—empty space; *b*—endosperm and *a*—embryo.

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serve as bracts. Adr. de Jussieu (1824), Roeper (1824), Wydler (1845), Alex. Braun (1853), De Candolle (1866), Warming (1873), Bentham and Hooker (1883), Eichler (1875) and Worsdell (1903) and several others accepted the basic principles of Brown's theory, disregarding some minor details.

Here also the inflorescence is a cyathium composed of several cymes, one solitary female flower and the rest numerous monandrous flowers arranged in scorpoid cymes. We entirely agree with the principles propounded and enunciated by Brown (1818).

Male flowers are monandrous with short filaments (Text-fig. 3) borne on longer pedicels. Bracteoles are scaly with smooth margins, columnar and elongated and their bases bulged out slightly sometimes with blunt tops (Text-fig. 10), at the axils of which the male flowers arise. The structure of the anther is depicted in Plate I, fig. 1. The anther is basifixed. Dehiscence takes place by longitudinal slits in the middle region. Slits are clearly observed up to the base of the anther lobe (Plate I, fig. 1). Blunt tops of the bracteoles take deeper stain when sections are stained (Text-fig. 10). The pedicel is whitish and paler in colour, whereas the filament is darker reddish.

There are divergent opinions regarding the interpretations of these staminate organs. Adanson (1763), Payer (1857), Baillon (1858) and Pederson (1873) held the opinion that these fundamental structures are articulated stamens. Schmitz (1871) believed that the anther was a metamorphosed axis, while Čelakovsky (1872) and Strasburger (1872) concluded that the flowers were composed of two sessile stamens. Schmidt (1906) found good analogy in the staminate flowers of several isolated genera of the same family. In these the 'perigone' was found above the articulation, and accordingly he believed that the axillary position of the stele terminated with the constriction and the upper half was phyllome (leaf) in nature.

Haber (1925) working out the floral anatomy of several species of the genus *Euphorbia* states that the part of the pedicel below the articulation is clearly on anatomical evidence of axial nature. The region of the articulation then is receptacular, upon which the flower is situated, and in function is similar to that of other receptacles. She added that there is not the slightest evidence that this stamen represents two fused stamens or is the remnant of a group of three. She states further, 'In ontogeny the vascular strands appear in the pedicel first and later the filament, as is the normal condition for axis and stamen. Hence, the stamen is situated upon a definite receptacle, which terminates the axis, a caulome structure, therefore a branch of the monochasium. Other evidence for the presence of two separated structures is the difference in colour between the pedicel and its phyllome.' For example, in *Euphorbia splendens*, the pedicel is dark purple and the filament is bright red. In *E. protulacoides* the presence of ridges upon all the pedicels of the monandrous flowers and then absent from the filaments of the anthers is a noteworthy evidence. In this species the pedicel and the filament are different in colour as stated above. And in our opinion Schmidt's views appear sound and tenable.

Further, much speculation exists on the interpretation of the bracteoles with reference to the flowers. Ontogenetic evidence regarding the morphology of the bracteoles is rather rare due to the difficulty in observing their development.

Adanson (1763) considered these non-descript structures as petals of individual flowers. Adr. de Jussieu (1824) and R. Brown (1818) designated them as bracts. Payer (1857) had characterized them as disc

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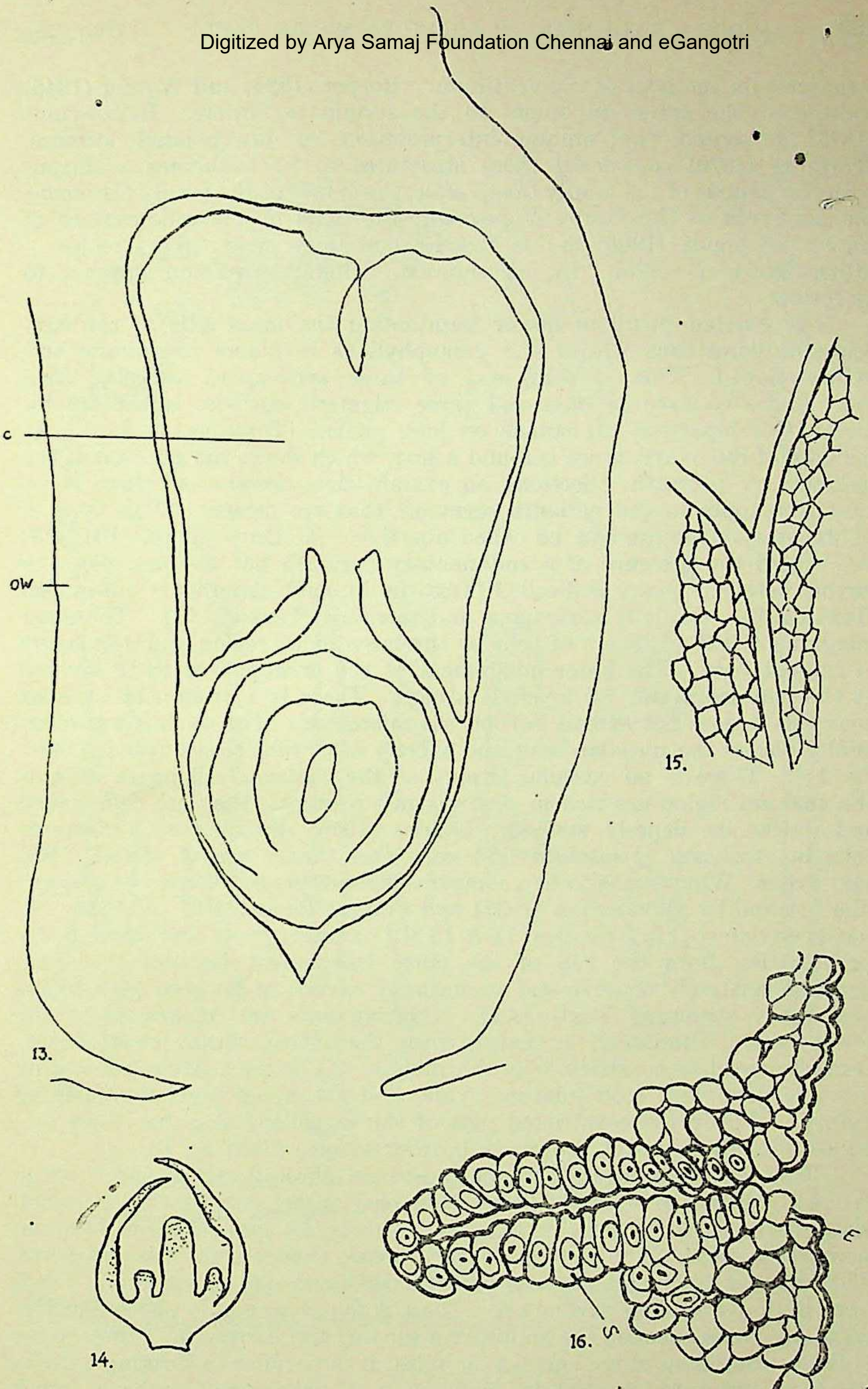

TEXT-FIGS. 13–16.

13. Radial section of an ovule showing that the caruncle (*c*) has developed from the outer integument; *ow*—ovarian wall. ×175.

14. Undeveloped cyathium bud. ×25.

15. Laticiferous vessel. ×100.

16. Section showing glandular details of the involucre. Gland or secretory cells (*s*)-uninucleate adjoining the gland; *E*—epidermis. ×300.

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structures on the floor of the cyathium. Roeper (1824) and Wydler (1845) considered the scales as bracts to the staminate flowers. Hieronymus (1872) presented the unique interpretation of interpolated stipules. Warming (1870) considered these structures to be trichomes analogous with the pappus of the family *Compositae*, the spines of the family *Cactaceae*, the perigynia of the family *Cyperaceae*, the hairs in the inflorescence of *Typha*. Schmidt (1906) in his treatise considers them as bracteoles of rather irregular origin. In our opinion, Schmidt's opinion appears to be correct.

The exerted pistillate flower terminating the main axis of the condensed inflorescence within the gamophyllous involucre is solitary and well-developed. This is composed of three syncarpous carpels, three short styles connate at base and three stigmatic surfaces which are bifurcated or bipartite. It stands on long pedicel (Text-figs. 2 & 5). At the base of the ovary, there is found a scar, which shows the position of the rudimentary perianth. Sections on examination reveal that there is no vascular supply in the perianth segments that are present. This type of rudimentary structure can be called abortive. N. Brown *et al.* (1911–13) also stated the presence of a rudimentary perianth but did not give any further details. Ovary is 3-celled (Text-fig. 5); each chamber is uni-ovuled (Text-fig. 6). Ovule is anatropous and bitegmic (Text-fig. 11). The inner integument is 8–10 layers of cells at the micropylar region and 4–8 layers of cells at base. The outer integument at the micropyle is 18-19 layered at the maximum and 5-6 layered at base. There is a prominent nucellar beak but it does not extend beyond the micropyle. The inner integument finally covers the nucellar beak and shortly afterward closes over it (Text-fig. 11). There is no vascular supply at the chalaza. Elongate cells at the chalazal region are rich in protoplasmic contents; they are thin-walled and nuclei are densely stained. Landes (1946) describes such elongate cells in *Acalypha rhomboidea* and calls this tissue central strand. She also writes, 'What seems to be a comparable structure is called a "hypostase-like" strand by Wünderlich (1938) and Sundar Rao (1940)' (p. 563). As has been depicted in Text-figs. 11 & 13 the caruncle grows and develops by proliferation from the top of the outer integument (exostome), which becomes relatively massive and at maturity covers up the seed with tubercled fleshy structure (Text-fig. 7). Ovarian cells are constricted at the lower part. Ultimately, in mature fruit the entire ovarian chamber becomes somewhat constricted in the middle, the lower portion containing a single pendulous seed (mature ovule) and the upper portion remaining empty. Within the constricted part of the carpellary chamber there is a cuneate tough placental outgrowth bearing nothing (Text-fig. 6).

Fruit is deeply-lobed leathery capsule of three 2-valved cocci. Seed is small oblong with white fleshy tubercled outer coat having a funnel-shaped structure at apex (Text-fig. 7). This is the type of caruncle found here in the seeds. The testa is leathery; inside the testa there is perisperm. The albumen here thus consists of both perisperm and endosperm. Seeds kept in dry conditions shrivel up. There is found an empty space developed in dry seeds between the endosperm-sac and the perisperm. Endosperm is fleshy consisting of copious fat globules; it is peculiar in forming a fleshy bag-like structure completely enveloping a very small embryo, much smaller than the surrounding endosperm recalling the habit of the genus *Daphniphyllum* (*Daphniphyllaceae*) but the cotyledons are broader. Radicle is superior and nearly as long as the cotyledons (Text-fig. 8). In our opinion the ensheathing structure at maturity is the endosperm bag (Text-fig. 12).

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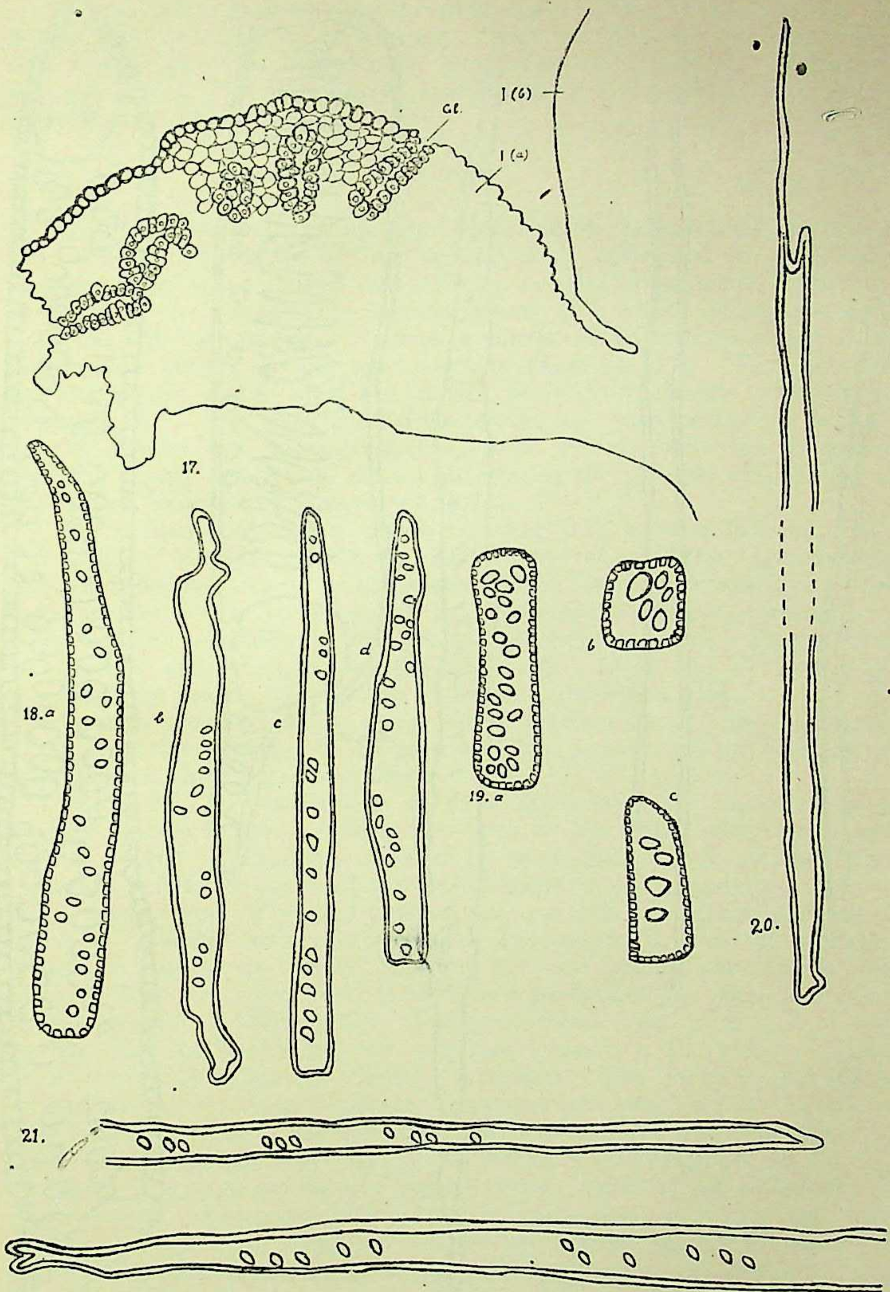

TEXT-FIGS. 17–21.

17. Section showing the position of glands in the involucre. × 75. $I(a)$—outer portion of involucre; $I(b)$—inner portion of involucre; Cl—gland and duct.
18. a, b, c, d. Tracheids of different sizes. × 300.
19. a, b, c. Pitted parenchyma of different sizes. × 300.
20. Wood fibre. × 300.
21. Wood fibre. × 300.

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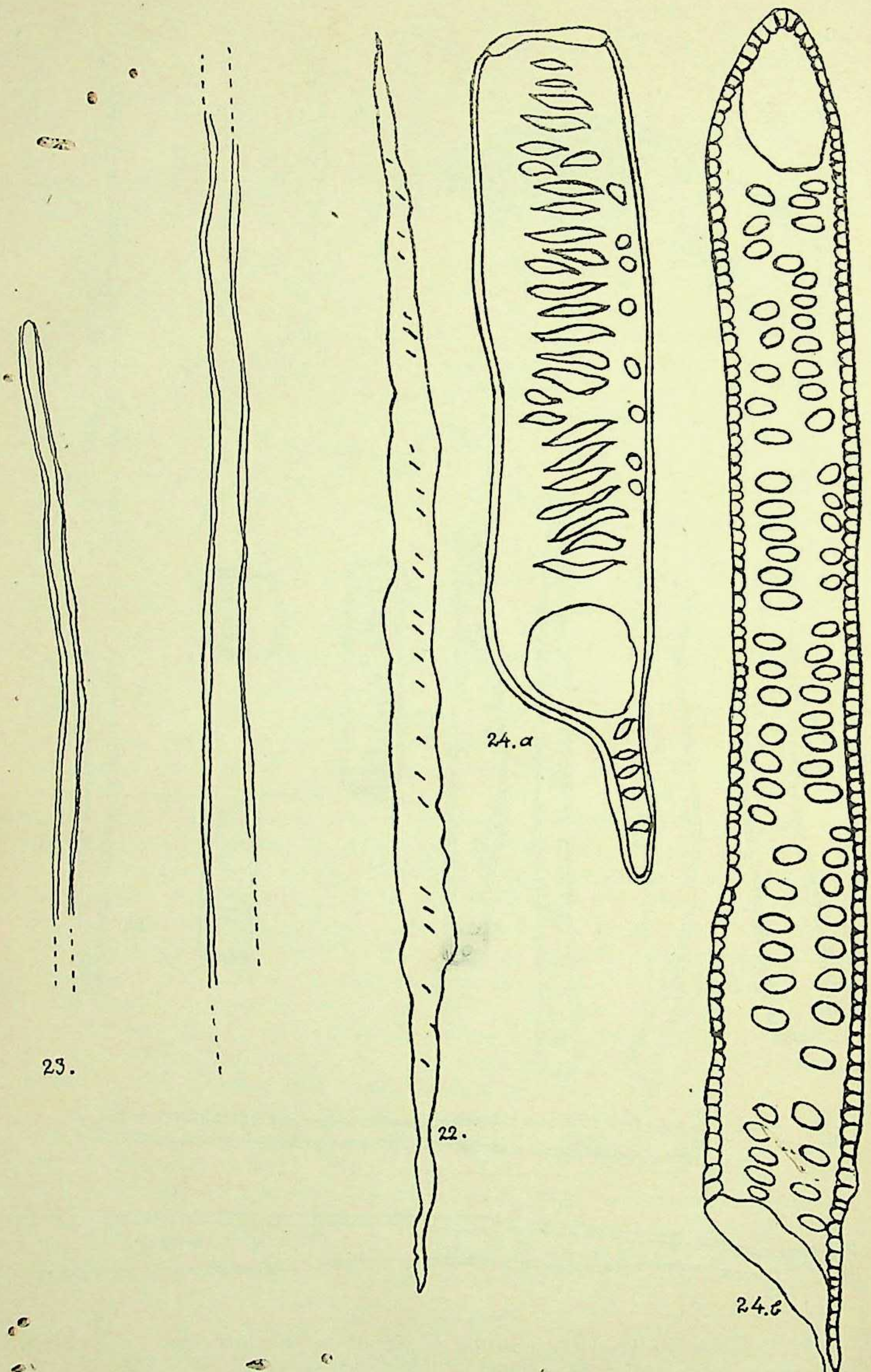

TEXT-FIGS. 22–24.

22. Wood fibre. $\times 300$.
23. Pericyclic fibre. $\times 300$.
24. *a*, *b*. Vessels with pitted thickenings (different sizes). $\times 300$.

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Mature pollen grains at the shedding stage is 2-nucleated (Text-fig. 9) and measure $40 \times 30\ \mu$ on an average. They are bicolpate and ellipsoidal with 2 germ pores on 2 prominent germ ridges and furrows. Walls are faintly reticulate but they appear smooth under low power of the microscope (Plate I, figs. 2 & 3).

Anatomy

Glandular structures or nectaries occurring on the involucre are many and secretory in nature. They are observed embedded in the tissue throughout in series in the outer fleshy cupular investment (Text-figs. 16 & 17). In sections the glands reveal thin-walled palisade-shaped epithelial cells surrounding the ducts or canals, which may be branched or simple; the outlets always open outside (Text-fig. 17). They contain abundant protoplasm and big nuclei and stain deeply with iron-haematoxylin. They are modified epidermal cells surrounding the canals. As the flowers are insect-pollinated, it is evident that the nectaries secrete a sugary solution to attract insects for the purpose of pollination as has been recorded by Haberlandt (1914).

In the stem laticiferous vessels together with laticiferous cells occur abundantly. Metcalf and Chalk (1950) write at p. 1215, 'Laticiferous cells, not always clearly distinguished from laticiferous vessels in the literature are said to be present in the *Acalyphae*, *Crotoneae*, *Euphorbieae*, *Hippomaneae*, especially in species....*Synadenium*....etc.' Latex tube is branched and unsegmented (Text-fig. 15). It is one of the main characters for placing *Synadenium* under the tribe *Euphorbieae*.

There is observed one vascular strand running throughout the length of the bracteole. Similar is the case with the pedicel and the filament of the stamen of the monandrous flower.

Adult stem in cross-section shows a single layer of cubical to rectangular epidermal cells. Walls are more or less thin; outer walls are slightly bulged out and are covered by moderately thick cuticle. The epidermis is followed by 2–5 layers of collenchymatous hypodermis, followed by many layers of cortical parenchymatous cells of irregularly rounded forms of variable size. Intercellular spaces are present moderately. Numerous laticiferous vessels, cells and sacs are present scattered in the cortex. They are more towards the inner portion of the cortical region. Endodermis is not well-defined. Pericyclic fibres occur in groups of 4–8 or more and also singly in a non-continuous ring over the phloem region. These pericyclic fibres are slightly thickened. The primary phloem is pressed and the secondary phloem represents comparatively few layers in comparison to xylem. The secondary xylem consists of wood parenchyma, tracheids, vessels and fibres and pitted ray cells (Text-figs. 18, 19, 20, 21, 22, 24). The rays are mostly single-layered consisting of pitted thick-walled linear rectangular cells; in rare cases 2-layered rays are also observed. Vessels are very few. They are present mostly in one layer radial chains; also a few occur singly. The primary xylem protrudes into the pith. The pith is very large and consists of thin-walled rounded parenchymatous cells. The intercellular spaces in the pith region are filled with some refractive materials. These are also found in some of the intercellular spaces in the cortex.

In mature stem, the pericyclic fibres become much more thickened and the secondary phloem is well laid out in radial tiers. These fibres are long linear. Their tips taper into acute points. They are thick-walled and straight in outline, only slightly uneven at places. Fibre ends are

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both even and uneven. Lumen of the fibres are narrow to moderate, irregular (Text-fig. 23).

The vessels are with simple perforations, with mostly pitted thickenings (Text-fig. 24). Rarely scalariform thickenings are also found. Wood fibres are of medium size and have usually simple linear pits, walls moderately thick (Text-figs. 20, 21 & 22). Tracheids are also present in a moderate degree and have bordered pittings (Text-fig. 18).

Further particulars will be subsequently communicated.

In the end, we offer our sincere and grateful thanks to Mr. Amiya Kumar Datta, Plant Anatomist, Jute Agricultural Research Institute, Barrackpore, for kindly going through the anatomical observations and suggesting improvements.

Summary

1. This species is reported for the first time from Bengal.

2. The bracts in the inflorescence region bear undeveloped branch buds at the axils.

3. The pedicel of the monandrous flower is whitish and paler, whereas the filament of the anther is darker reddish.

4. Ovule is bitegmic and anatropous and possesses prominent nucellar beak.

5. Caruncle develops by proliferation from the top of the outer integument (exostome).

6. Pollen grains are binucleate at the shedding stage. They are bicolpate, ellipsoidal with 2 germ pores.

7. Involucre contains simple or branched nectaries.

8. Laticiferous cells, vessels and sacs occur.

9. Pericyclic fibres occur singly or in groups.

10. Intercellular spaces in the cortex and the pith contain some refractive materials.

11. Vessels are with simple perforations with pitted thickenings. Scalariform thickenings rarely occur.

12. Wood fibres are of medium size and have simple linear pits. Tracheids with bordered pittings also occur.

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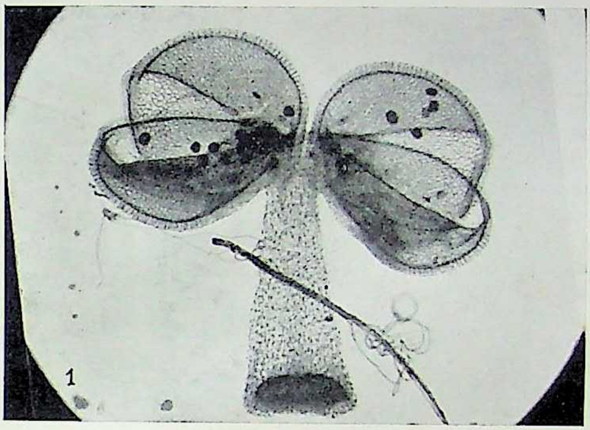

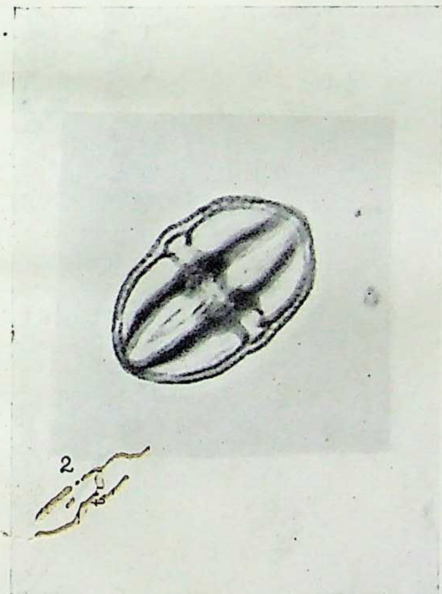

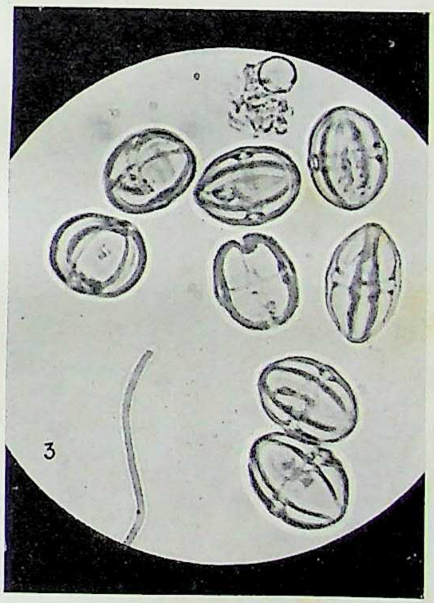

FIG. 1. Stamen showing dehiscence.
FIG. 2. One single pollen grain highly magnified showing germ furrows and ridges.
FIG 3. Pollen grains in optical and side views.

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FISH-HOOKS FROM THE INDUS VALLEY

By Haribishnu Sarkar

(Communicated by Dr. S. L. Hora)

(*Paper received on 12th September, 1952*)

Introduction

The art of angling seems to have reached a high level of perfection in ancient India. The earliest work on angling, so far known and recorded belongs to India, as shown by Hora (1951) in his recent researches on Someśvara's '*Mānasollāsa*', a Sanskrit work of the early 12th century. Hora has shown that the knowledge embodied in 'Matsyavinoda', a chapter of this work, is the result of a long accumulation of 'factual and deductive data' on angling, fishes and fisheries of India. In the present paper, an attempt is made to examine from the different points of view the archaeological data on fish-hooks from the Indus valley with reference to their typological connection with modern specimens.

Apart from the Indus Valley, and with the single exception of the Sisupalgarh hook (Lal, 1949) of problematic identification, no other excavated or explored site has yet brought to light any specimen of fish-hooks in India. At the same time, the aboriginal tribes of India, as a whole, appear to be ignorant of the method of fishing by hooks. The few instances of fishing by hooks, either made of umbrella wire (Hutton, 1921) or bought from the local markets, are recent adoptions. The Maria Gonds (Grigson, 1938) use thorns as hooks to catch fish. 'Curved-back' thorns of certain kinds of rattan (*Calamus*) are used as fish-hooks by the Sakai of Malay Peninsula (Skeat and Blagden, 1906). Radcliffe (1921) has published photographs of a natural fish-hook from New Guinea made of 'the thick upper joint of the hind leg of an insect, *Eurycantho latro*'. Fish-hooks made of turtle-shell, bone or wood are widespread among the aboriginal peoples of the Pacific Islands, North America and East Africa. Lagercrantz (1934) has shown that there are two centres of indigenous fish-hooks in Africa: one in E. Africa and the other in Congo. No such indigenous types of fish-hooks are met with among the aborigines of India. Fishing by gorge[1] hooks is however, practised in the case of *Koi* (*Anabas*) fishes in paddy fields ~~of~~ East Bengal and is probably one of the local indigenous methods. ~~It~~ is probably unknown in West Bengal.

Fish-hooks of the Indus Valley

The fish-hooks of the Indus Valley can be classified into two main types: (1) Barbed and (2) Unbarbed. Specimens of 16 fish-hooks from Mohenjodaro have been mentioned by Marshall (1931) and Mackay (1938), while the Harappa report includes only 1 specimen. Chanhudaro has

[1] 'The simplest form of the hook is that known as gorge hook—a spike of bone or wood sharpened at both ends and fastened at the middle of the line.' (Bonnerjee, 1938.) The gorge hooks of Bengal are thin flexible piece ~~of bamboo~~ strips doubled up to form a loop. The fine sharpened ends, inserted into the body of a live bait, spring straight at the bite of the fish. It is similar to the gorges of China. Thomas (1897) mentions common pike gorge hooks for catching eels in India.

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yielded 7 specimens including Majumdar's (1934) collection. Of the Mohenjodaro specimens, all the 16 are barbed, while of the Chanhudaro finds 3 are barbed and 4 are unbarbed. The solitary specimen from Harappa is unbarbed. The paucity of fish-hooks at Harappa may show that angling was not popular at this place. This may be due to the nature of the two rivers as well, the Ravi and the Indus. The latter was probably a richer source of fishing than the former.

Relative sizes of the Indus Valley Fish-hooks

The Indus Valley fish-hooks differ in their relative sizes which evidently shows that hooks of different sizes were employed for catching different kinds of fishes. Modern fish-hooks also vary in types and sizes according to the type and size of the fish to be caught. A comparison (Table I) of the Indus Valley fish-hooks with some of the present-day specimens,[1] available in Calcutta markets, is worth studying.

It will be seen from Table I that the fish-hooks of the Indus Valley range from 2·9″ to 0·43″ in length whereas the modern specimens from Calcutta markets range between the maximum length of 3·8″ to the minimum length of 0·31″. It will also be seen that there is a close agreement in certain lengths, *i.e.* 2·2″, 1·8″, 1·2″, 1·1″ and 0·4″ between the two sets of comparative data. The gradients in the lengths of the two series vary in the following manner:

Indus Valley .. 0·4″, 1·0″, 1·1″, 1·2″, 1·3″, 1·5″, 1·7″, 1·8″, 1·9″, 2·0″, 2·3″ and 2·9″.
Modern .. 0·3″, 0·4″, 0·5″, 0·6″, 0·7″, 0·8″, 0·9″, 1·0″, 1·1″, 1 2″, 1·3″, 1·4″, 1·5″, 1·6″, 1·8″, 2·2″, 2·5″, 3·8″.

The remarkable difference lies in the modern fish-hooks having 5 types, *i.e.* 0·5″, 0·6″, 0·7″, 0·8″, 0·9″ towards the lower end of the gradient. Between the minimum size of 1″ and the maximum of 2·3″ there are 8 different types in both the Indus Valley and the modern specimens. This shows that there is a fair degree of similarity not only in typology between the two sets of data but also in the nature of the fish caught.

In breadth,[2] the Indus Valley types vary between the minimum of 0·06″ and the maximum of 0·2″, while the modern types vary between the minimum of 0·1″ and the maximum of 1·4″. The gradients of the breadths are as follows:

Indus Valley .. 0·06″, 0·08″, 0·09″, 0·11″, 0·12″, 0·13″, 0·15″, 0·18″, 0·19″, 0·20″, 0·21″.
Modern .. 0·1″, 0·2″, 0·3″, 0·4″, 0·5″, 0·6″, 0·7″, 0·9″, 1·0″, 1·2″, 1·4″.

It will be seen from the above that both the Indus Valley and the modern hooks show 11 types in each case.

At the suggestion of Dr. Hora the lengths and breadths of the fish-hooks have been expressed into a proportion of length/breadth, which is given against each hook in Table I. It will be seen therefrom, that while the Indus Valley hooks vary between the proportions of 6·93 and 16·25, the

[1] The variety of modern fish-hooks is enormous and they require a monographic study of their own. The variety of forms together with their distribution in various parts of the world, which appear to be zonal in nature, necessitates a detailed ethnographic study. Two such works (Bonnerjee, 1938 and Lagercrantz, 1934) covering North America and Africa have already appeared.

[2] The breadth of 0·9″ of the solitary Harappa find is probably an error.

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TABLE I—*Fish-hooks from Indus Valley compared with modern fish-hooks*
(Arranged in order of length)

INDUS VALLEY (Cf. Fig. 1)					MODERN (Cf. Pl. 1, Row 4–7)			
Excavation No.	SIZE	Length/Width	LOCALITY	REFERENCE	Plate I	SIZE	Length/Width	TYPES OF FISH CAUGHT
11156	2·9″ × 0·19″	15·26	Mohenjodaro ..	Mackay (1938)	1	3·8″ × 1·4″	2·71	Very large fish.
DK10568	2·31″ × 0·21″	11·00	,, ..	,, ..	9	2·5″ × 0·91″	2·70	
HR3312	1·95″ × 0·12″	16·25	,, ..	Marshall (1931)	2	2·2″ × 0·76″	2·89	
10781	1·9″ × 0·18″	10·56	,, ..	Mackay (1938)	3	1·8″ × 0·68″	2·65	
8154	1·9″ × 0·15″	12·67	,, ..	,, ..	4	1·6″ × 0·64″	2·50	For fishes caught by live bait.
3487	1·87″ × 0·15″	12·47	Chanhudaro ..	Mackay (1943)	17	1·5″ × 1·20″	1·20	
					18	1·3″ × 1·01″	1·20	
8259	1·75″ × 0·13″	13·46	Mohenjodaro ..	Mackay (1938)	10	1·3″ × 0·51″	2·50	Used for catching bigger sizes of Rohit, Catla, etc.
1057	1·75″ × 0·9″	..	Harappa ..	Vats (1940) ..	4	1·2″ × 0·48″	2·50	
					9	1·2″ × 0·47″	2·50	
3641	1·68″ × 0·11″	15·27	Chanhudaro ..	Mackay (1943)	6	1·2″ × 0·40″	3·00	
					19	1·15″ × 0·75″	1·53	
					12	1·10″ × 0·44″	2·50	
DK4140	1·65″ × 0·15″	11·00	Mohenjodaro ..	Marshall (1931)	24	1·06″ × 0·53″	2·00	*Labeo rohita*, *Cirrhina*, *Mrigala*, *Catla catla*, etc.
					14	0·90″ × 0·73″	1·20	
					20	0·83″ × 0·56″	1·40	
7375	1·5″ × 0·2″	7·50	,, ..	Mackay (1938)	23	0·87″ × 0·59″	1·40	
					13	0·74″ × 0·25″	2·90	
					25	0·68″ × 0·55″	1·20	
3[illegible]12	1·28″ × 0·12″	10·67	Chanhudaro ..	Mackay (1943)	7	0·68″ × 0·28″	2·43	
					21	0·61″ × 0·40″	1·50	
					15	0·64″ × 0·24″	2·60	For small fishes.
4140	1·25″ × 0·18″	6·94	Mohenjodaro ..	Mackay (1938)	22	0·52″ × 0·35″	1·40	
					26	0·55″ × 0·23″	2·30	
3038	1·22″ × 0·09″	13·56	Chanhudaro ..	Mackay (1943)	27	0·41″ × 0·14″	2·90	
					16	0·31″ × 0·14″	2·20	
					8	0·31″ × 0·11″	2·80	
2943	1·12″ × 0·08″	14·00	,, ..	,,				
8152	1·04″ × 0·15″	6·93	Mohenjodaro ..	Mackay (1938)				
48[illegible]A	0·43″ × 0·06″	7·17	Chanhudaro ..	Mackay (1943)				
Average	1·61″ × 0·14″	11·54				1·14″ × 0·54″	2·17	

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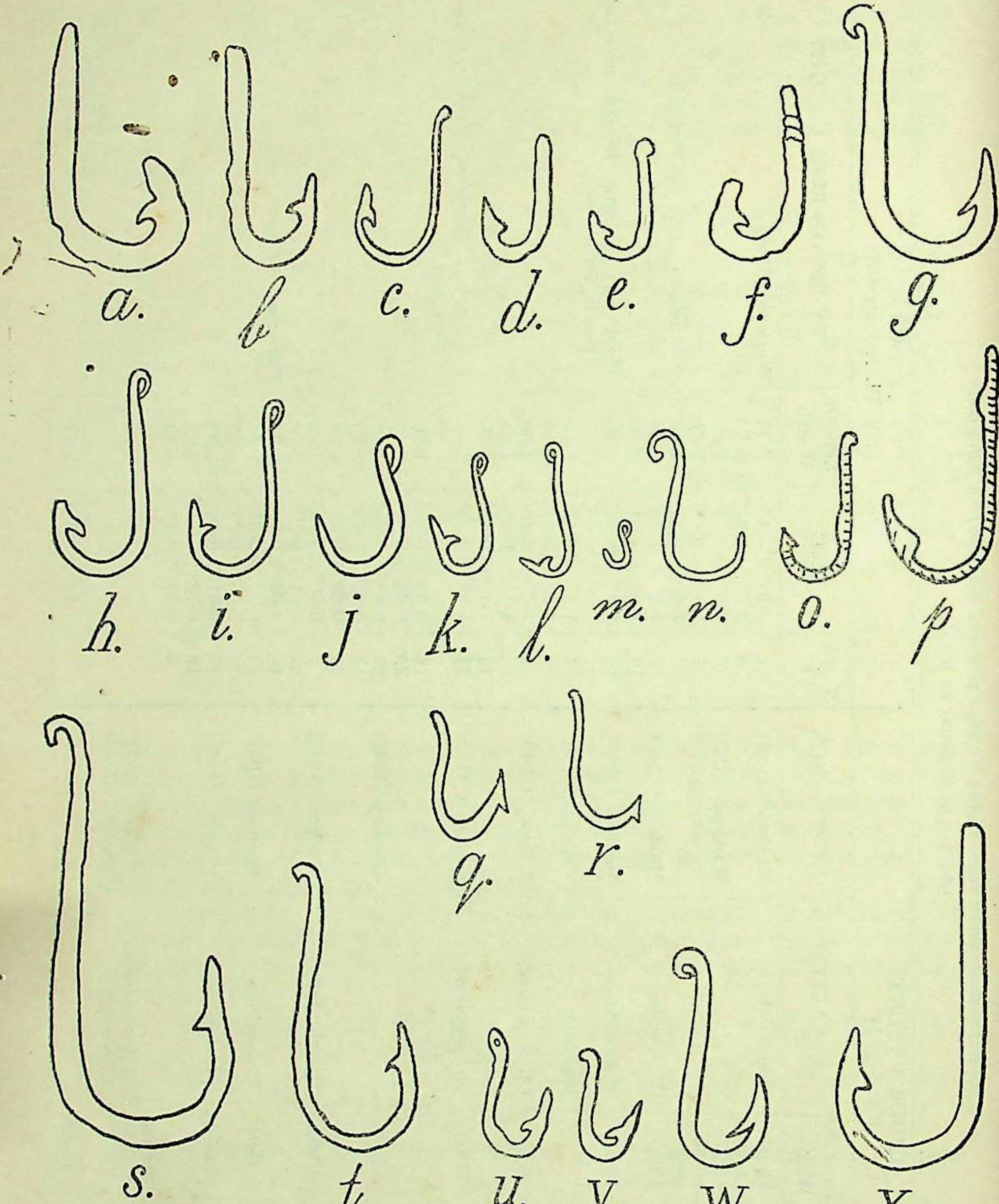

FIG. 1

Indus Valley Hooks

a—7353, *b*—8154, *c*—8259, *d*—4140, *e*—11923, *f*—7375, *g*—10568, Mohenjodaro (Mackay); *h*—3487, *i*—3641, *j*—3812, *k*—2943, *l*—3038, *m*—488A Chanhudaro; *n*—1057 Harappa; *o*—Kish; *p*—Ur (Hall); *q*-*r*—Ur (Woolley); *s*—3312, *t*—4140 Mohenjodaro (Marshall; *u*—9276, *v*—8152, *w*—10781, *x*—11156 Mohenjodaro (Mackay).

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modern hooks vary between 1·20 and 3·00. This appears to be mainly due to the wide variability in the breadth of the Indus Valley fish-hooks; the lengths of the two series being more or less constant. It will be obvious from the average figures of the two series.

Among the Indus Valley hooks themselves, the Mohenjodaro specimens vary between the lengths of 2·9″ and 1·04″, whereas the Chanhudaro hooks vary between the lengths of 1·87″ and 0·43″. This difference in the relative sizes of the hooks indicate that at Chanhudaro fishing was probably confined to tanks and small streams, whereas at Mohenjodaro all fishing was done in the Indus. The fish bones unearthed from Mohenjodaro (Sewell, 1931) and Harappa (Prasad, 1936) indicate the following types:

Mohenjodaro .. *Rita rita*, *Wallago* sp., *Arius* sp. and typical remains of a carp;
Harappa .. *Rita rita*, fragmentary remains of a carp.

It thus appears from the list that apart from freshwater riverine and tank fishes, the Indus Valley people also used fishes belonging to the estuarine forms of the *Arius* species.

Evolution of Barbs at Chanhudaro.

The evolution of barbs at Chanhudaro is worthwhile describing in detail as it appears that the barbing process underwent some experimentation at this place. It will be evident from the figures (Fig. 1, Chanhudaro). The hook No. 3038 (Fig. 1, *l*) has a barb at the centre of the hook, whereas Nos. 2943 (Fig. 1, *k*) and 3641 (Fig. 1, *i*) have their barbs made by a V-shaped fork at the end. The final and perfect form is seen in No. 3487 (Fig. 1, *h*). It thus appears that the fish-hooks of the Indus Valley reached their final and perfect form at the 4th stage. The gradual stages appear to be:

1. Barbless (Fig. 1, *j*, *m*, *n*).
2. Barbed nearly at the centre (Fig. 1, *l*).
3. Barbed outwards at the end (Fig. 1, *a*, *b*, *c*, *i*).
4. Barbed inwards at the lower half (Fig. 1, *u*, *w*).

Chanhudaro has yielded the only example of a hook with a central barb whereas fish-hooks with barbs opened outwards at the end have been reported from Africa (Lagercrantz, 1934, Fig. 7). The similarity between the African and Chanhudaro specimen is striking. Ur has also yielded two fish-hooks with end barbs but their similarity with the Chanhudaro finds is only in having the barb at the end. The actual barbs are different.

So far as the other end of the hook is concerned, the Indus Valley has yielded more than one variety. Mackay (1938) holds that it generally consists of 'a straight shank slightly thinned out and turned over to form an eye at the top'. As will be evident from the figures, three distinct types are clearly distinguishable. They are :

(1) Hooks consisting of a straight shank without forming any curve or eye. Ur specimens are very similar to this type of shank. Thomas (1897) furnishes illustrations of modern hooks with straight shanks.
(2) Hooks consisting of straight shanks but turned outwards, the bent loop does not touch the shank.
(3) Hooks consisting of a straight shank but curved out to form a small eye, which is either connected with the shank or only slightly separated from it. There is one specimen in which the eye is turned sideways.

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Fish-hooks at other Archaeological Sites

Lagercrantz has shown a long gap between the barbed and barbless hooks in Egypt. Barbless hooks appear towards the end of the Predynastic era, (*ca.* 4000 B.C.) whereas barbed hooks appear for the first time during the 12th dynasty (*ca.* 2200 B.C.–2000 B.C.). The presence of both the barbed and barbless hooks at the Indus Valley (not earlier than *ca.* 3250 B.C.) together with the variation in relative sizes and of the barbs at the various position of the hook, is probably an independent character of the Indus Valley culture.

Ur has produced two examples with end barbs which are not real barbs. It will be fair to describe them as butts and not barbs. The Ur specimens (Woolley, 1934) differ from the Indus Valley specimens in the line end of the hook and in this as well, a gradual evolution in the Chanhudaro specimens is obvious. The peculiar hook with a central barb is undoubtedly of a simpler design than No. 2943 (Fig. 1, *k*). Its final form is evidently No. 3487 (Fig. 1, *h*). Another find from Ur (Hall and Woolley, 1927) has some resemblance to certain specimens from Mohenjodaro, so far as the barb is concerned, but the workmanship appears to be crude. Mackay (1925) has discovered the only fish-hook in the 'A' mound at Kish and the specimen very closely resembles the Indus Valley ones. Fish-hooks with bored holes on shell or bone as eyes for threading are only peculiar to Egypt. They have been found at Matmar (Brunton, 1948) which probably dates to the Badarian period.

Conclusion

It appears from the above facts that the best type of metallic fish-hooks was probably developed at the Indus Valley. In fact it attained the best perfection of all the fish-hooks at similar sites in Egypt and Mesopotamia. Their agreement with modern fish-hooks may be the continuity of a culture-trait similar to that found in pottery designs by Mackay (1930).

Acknowledgment

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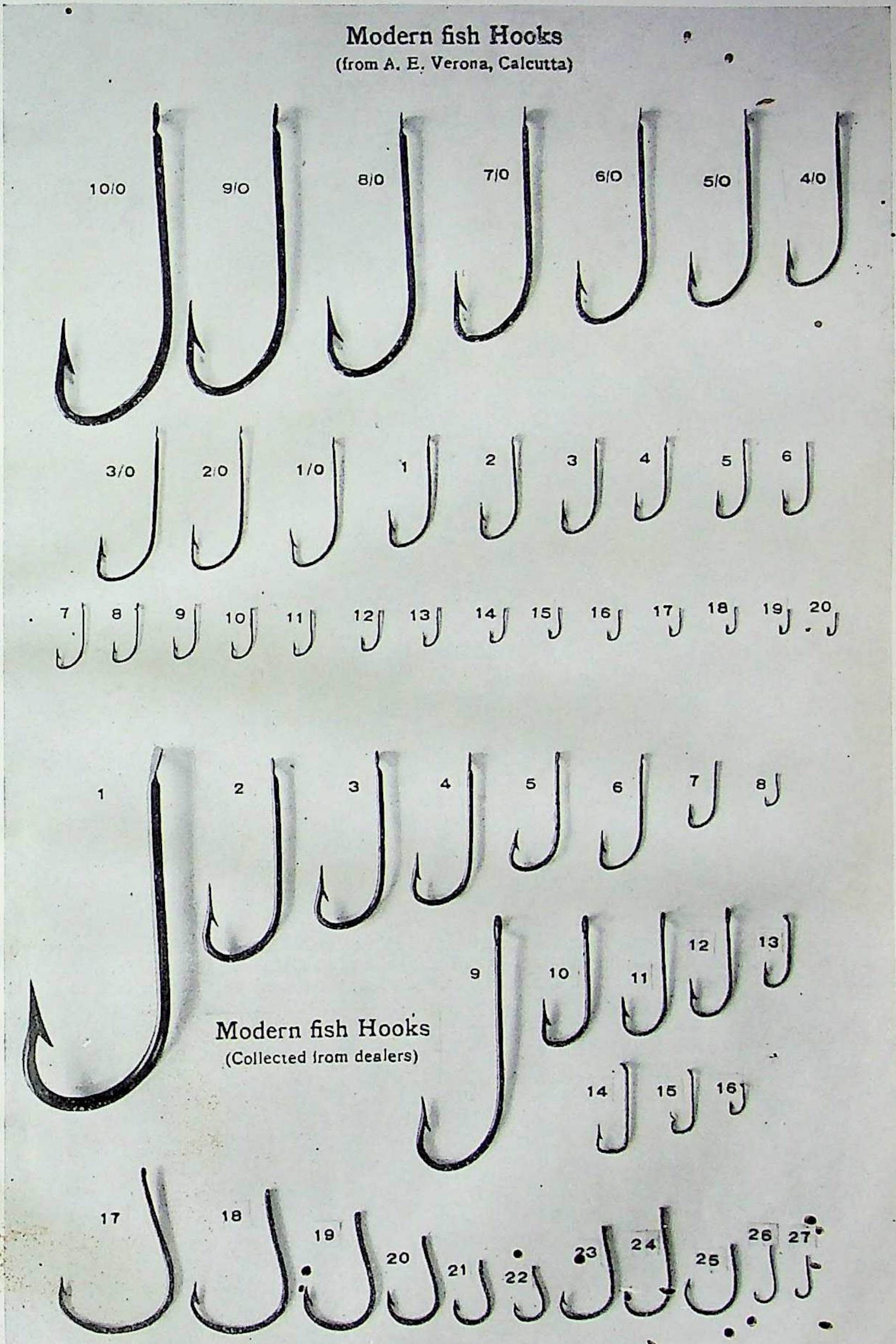

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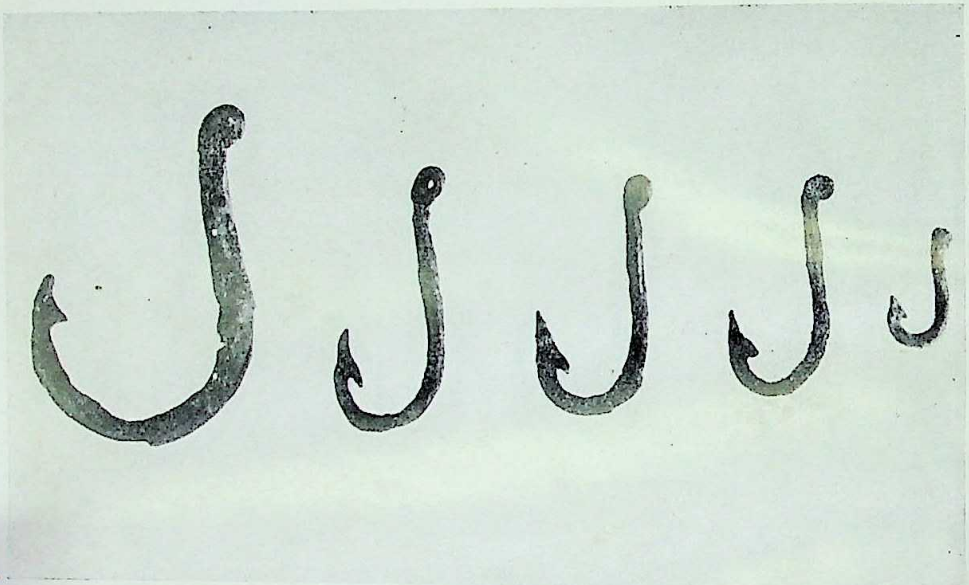

Undescribed Mohenjodaro fish hooks (courtesy of Director-General of Archaeology through Dr. S. L. Hora, Director, Zoological Survey of India) found in DK Area, G. Section, during the season 1928-29. Excavation Nos. DK 6048, 6532, 6083, 6342 and 7617, from left to right.

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GENERA OF THE HEPIALIDAE (INSECTA, LEPIDOPTERA)

सन्दर्भ ग्रन्थ
REFRENCE BOOK

By JIŘÍ PACLT

यह पुस्तक वितरित न की जाय
NOT TO BE ISSUED

(Communicated by [illegible] Sen)

(*Paper received on 9th September, 1952*)

There are few families in Lepidoptera which of recent years have been so rapidly enriched by the erection of several new genera as the *Hepialidae*. Thus VIETTE himself described, in the period 1948–1951, nearly twenty-five new genera (some of which he indicated originally as subgenera), i.e. an increase of 125% of genera over these catalogued by WAGNER and PFITZNER in 1911. How to explain this unusual increase? On the one hand, we may admit that the *Hepialidae* was less studied, a negligence which is typical of the interest of the majority of entomologists for some groups like the 'micros' among the Lepidoptera. On the other hand, we must emphasize the rôle of the modern strict specialization which eventually and almost indirectly leads to an excessive splitting up of certain taxa. Already in 1929, the well-known zoological authority, late Professor HANDLIRSCH, warned all colleagues not to split up unnecessarily individual genera and other taxa, as sufficient reasons to do so are not present in all cases (see Bibliography). In the meantime, a just opposite method is promulgated by some recent schools of lepidopterologists (VERITY, HEMMING, etc.). If we search after some direct motives influencing the act of splitting the known genera and making a number of new ones from these, we find one reason in overrating the importance of the genital armature as a taxonomic criterion. ELTRINGHAM (1922) rightly wrote: '. . . the structure of the male armature is rarely to be relied on as an indication of more than specific affinity'. This is also the view of FORD (1947) and some other biologists, and I confirm this opinion. Naturally, the view must not be limited merely to the male armature and likewise the female armature cannot be regarded as an indication of more than specific affinity. Now, similar trends to split the genera on basis of different characters of the genitalia only are evident also among the *Hepialidae* (e.g., in *Philpottia* VIETTE, *Paraoxycanus* VIETTE, *Pseudophilaenia* VIETTE, *Hampsoniella* VIETTE, *Xytrops* VIETTE, *Alloaepytus* VIETTE, *Pseudodalaca* VIETTE, *Parana* VIETTE, *Blanchardina* VIETTE, etc.). This has resulted in considerable increase of the genera described recently in that family. One cannot be surprised under such circumstances when JANSE (1942) wishes to solve the problem of the synonymy between *Leto* HBN., and *Zelotypia* SCOTT only on the basis of a study of the genitalia. Once a specialist (in litteris) writes, 'Les genitalia sont les seules choses qui renseignent bien chez les *Hepialidae*'.

Although serious efforts have been made recently by few authors, especially TINDALE, to revise and work out a system of relationship of several new forms and genera of the *Hepialidae*, our knowledge is still imperfect. I have attempted, however, to revise the classification of these primitive moths, in the following key. For the purpose of verifying

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the identification of an insect pertaining hitherto in conjunction with the original literature, a selected list of references has been included. Chapters on new synonymy of genera, genera not belonging to *Hepialidae*, and new additional genera, and some rectifications in the identification of certain genera and species are also added. The key is accompanied by a table indicating the geographical distribution of each genus.

Key to the genera *

1. Forewings with R_4 out of R_2..2
   Forewings with R_4 not out of R_2..8
2. Forewings with R_1 and R_2 well developed..3
   Forewings with R_1 and R_2 only weakly developed, R_2 practically absent..*Trichophassus* Le Cerf
3. Forewings with R_1 and R_2 separate from near base..4
   Forewings with R_1 anastomosed with R_2 near branching off of R_4, thus forming a small cell between R_4 and R_5; sexual dimorphism in venation of hindwings; labial palpi two-segmented..*Elhamma* Walk.
4. Labial palpi distinct, three-segmented..5
   Labial palpi indistinct..6
5. R_2 and R_3 branching much nearer to termen than to junction with R_4; labial palpi long and slender, basal segment longer than second; antennae bipectinate..*Jeana* Tindale
   R_2 and R_3 branching nearer to R_4 than to termen; labial palpi moderate, porrected, second segment longer by about half than first; antennae bipectinate or bidentate..*Oxycanus* Walk.
6. Prothoracic legs with epiphysis..7
   Prothoracic legs without epiphysis; antennae filiform *Hepialiscus* Hmps.
7. Antennae filiform..*Parahepialiscus* Viette
   Antennae crenulate..*Neohepialiscus* Viette
8. Antennae tripectinate; labial palpi very distinct......*Trictena* Meyr.
   Antennae never tripectinate..9
9. Antennae bipectinate or bidentate..10
   Antennae other than bipectinate (bidentate)..17
10. Labial palpi distinct..11
    Labial palpi moderate, rather indistinct..12
11. Pectinations of antennae, especially in ♂, many times as long as wide; forewings with R_4 and R_5 shortly stalked; front tibiae with epiphysis..*Gorgopis* Hbn.
    Pectinations of antennae, even in ♂, approximately as long as wide, or only slightly longer; forewings with R_4 and R_5 not stalked..*Parapielus* Viette
12. Abdominal tergite VIII, in ♂, asymmetric..*Pseudophassus* Pfitz. and Gaede
    Abdominal tergite VIII, in ♂, symmetric..13
13. Forewings with R_4 and R_5 stalked..14
    Forewings with R_4 and R_5 not stalked..15
14. Antennae in ♂ bipectinate..*Fraus* Walk.
    Antennae in ♂ bidentate..*Eudalacina* Paclt

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* *Cibyra* Walk., *Pfitzneriella* Viette and *Metahepialus* Janse being very little known genera, are not included here.

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15. Front tibiae without epiphysis 16
Front tibiae with epiphysis .... *Eudalaca* VIETTE
16. Antennae bipectinate in both sexes .... *Bordaja* TINDALE
Antennae in ♂ bipectinate, in ♀ deeply bidentate .... *Aepytus* H.-S.
17. Antennae subclavate, composed of relatively few segments (almost 14 to 20) and clothed usually with large flattened scales ....
.... *Oncopera* WALK. (incl. subg. *Paroncopera* TINDALE)
Antennae not subclavate and never clothed with large scales 18
18. Antennae in ♂ uniformly filiform, segments not enlarged 19
Antennae in ♂ either unipectinate or more or less crenulate 27
19. Forewings in ♂ with scent gland placed in thickening of wing ....
.... *Phassodes* BETH.-BAK. and *Puermytrans* VIETTE *
Forewings in ♂ without scent gland 20
20. Hindwings in ♂ partially tufted with long rough hairs; front tibiae with epiphysis .... *Leto* HBN. (incl. subg. *Zelotypia* SCOTT)
Hindwings in ♂ without tufts of long rough hairs 21
21. Maxillary palpi well developed; labial palpi two-segmented; metathoracic legs in ♂ modified, bearing an odoriferous organ ....
.... *Zenophassus* TINDALE
Maxillary palpi obsolete or absent 22
22. Labial palpi well developed 23
Labial palpi indistinct 25
23. Antennae longer than 5 mm 24
Antennae shorter than 5 mm.; front tibiae (so far as known) without epiphysis .... *Palpifer* HMPS.
24. Antennae composed of about 37-38 segments (excluding scapus and pedicellus); front tibiae with epiphysis .... *Lossbergiana* VIETTE
Antennae with about 42–48 segments (excluding scapus and pedicellus); front tibiae apparently with epiphysis .... *Callipielus* BUTLER
25. Front tibiae with epiphysis .... *Gazoryctra* HBN.
Front tibiae without epiphysis 26
26. Hind legs in ♂ with largely modified tibiae, bearing an odoriferous organ .... *Phymatopus* WALLGR.
Hind legs in ♂ with more or less reduced tibiae, but not largely modified; a group of genera comprising very heterogeneous elements, which should be revised; *Phassus* WALK. (including *Endoclyta* FELDER, *Sahyadrassus* TINDALE, *Nevina* TINDALE, *Tricladia* FELDER); *Hepialus* FABR. (including *Antihepialus* JANSE, *Sthenopis* PACK., *Charagia* WALK., *Procharagia* VIETTE); *Schausiana* VIETTE
27. Forewings with Cu_2 reaching margin .... *Triodia* HBN.
Forewings with Cu_2 not reaching margin 28
28. Labial palpi well developed; front tibiae with or without epiphysis
....29
Labial palpi rather indistinct; front tibiae with epiphysis 30
29. Antennae usually with more than 50 clavola segments; front tibiae (so far as known) without epiphysis .... *Abantiades* H.-S.
Antennae usually with less than 45 clavola segments; front tibiae with epiphysis .... *Dalaca* WALK.
30. Antennae usually with more than 30 clavola segments ....
.... *Roseala* VIETTE
Antennae usually with less than 30 clavola segments ....
.... *Schaefferiana* VIETTE

* A differential diagnosis of the two genera has not been given by VIETTE (1951*b*).

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Table showing geographical distribution of the *Hepialidae* *

Genus	Key No.	AU	IN	PA	ET	NO	NA
Trichophassus	2	–	–	–	–	+	–
Elhamma	3	+	–	–	–	–	–
Jeana	5	+	–	–	–	–	–
Oxycanus	5	+	–	–	–	–	–
Hepialiscus	6	–	+	–	–	–	–
Parahepialiscus ..	7	–	+	–	–	–	–
Neohepialiscus	7	–	–	+	–	–	–
Trictena	8	+	–	–	–	–	–
Gorgopis	11	–	?	?	+	–	–
(*Metahepialus*)	..	–	–	–	+	–	–
Parapielus	11	–	–	–	–	+	–
Pseudophassus	12	–	–	–	–	+	–
Fraus	14	+	–	–	–	–	–
Eudalacina	14	–	–	–	+	–	–
Eudalaca	15	–	–	–	+	–	–
Bordaja	16	+	–	–	–	–	–
Aepytus	16	–	–	–	–	+	–
Oncopera	17	+	–	–	–	–	–
Phassodes	19	+	–	–	–	–	–
Puermytrans	19	–	–	–	–	+	–
Leto	20	+	–	–	+	–	–
Zenophassus	21	–	–	+	–	–	–
Palpifer	23	–	+	+	–	–	–
Lossbergiana	24	–	–	–	–	+	–
Callipielus	24	–	–	–	–	+	–
(*Pfitzneriella*)	..	–	–	–	–	+	–
Gazoryctra	25	–	+	+	+	–	+
Phymatopus	26	–	–	+	–	–	+
Phassus	26	–	–	–	–	–	+
(*Endoclyta*)	26	–	+	+	?	–	–
(*Sahyadrassus*) ..	26	–	+	–	–	–	–
(*Nevina*)	26	–	+	–	–	–	–
(*Tricladia*) †	26	–	–	–	–	+	–
Hepialus	26	–	–	+	?	–	?
(*Antihepialus*)	26	–	–	–	+	–	–
(*Sthenopis*)	26	–	+	?	–	–	+
(*Charagia*)	26	+	–	–	–	–	–
(*Procharagia*)	26	–	+	–	–	–	–
Schausiana	26	–	–	–	–	+	–
Triodia	27	–	–	+	–	–	–
Abantiades	29	+	–	–	–	–	–
Dalaca	29	–	–	–	–	+	–
Roseala	30	–	–	–	–	+	–
Schaefferiana	30	–	–	–	–	+	–
(*Cibyra*)	..	–	–	–	–	+	–

New Synonymy in Genera

(1) *Achladaeus* H.-S. = An absolute nomen nudum.

(2) *Aegiochus* H.-S. = An absolute nomen nudum.

(3) *Aenetus* H.-S. (= *Oenetus* auct.) = A nomen nudum; no species has been cited and no diagnosis has been given. KIRBY's 'fixation' of *Hepialus lignivora* /sic!/ LEW. falls, therefore, to the ground. The name is to be neglected in favour of *Charagia* WALK. See also VIETTE 1950 f.

* Abbreviations used for the regions: AU = Australian, IN = Indian, PA = Palearctic, ET = Ethiopian, NO = Neotropic, NA = Nearctic.

† 'Tricladia' *papuana* OB. is said to occur in New Guinea (AU).

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(4) *Alloaepytus* VIETTE 1950 c = *Aepytus* H.-S.
(5) *Blanchardina* VIETTE 1950 e = *Dalaca* WALK.
(6) *Druceiella* VIETTE 1949 a, type *Hepialus momus* DRUCE = *Pseudophassus* PFITZ. and GAEDE (Seitz's Grosschmetterlinge Erde 6 : 1301, 1938), type *Hepialus prosopus* DRUCE (selected by VIETTE 1950 i).
(7) *Hampsoniella* VIETTE 1949 g = *Aepytus* H.-S.
(8) *Hepialyxodes* VIETTE 1951 b = *Aepytus* H.-S.
(9) *Korscheltellus* BÖRNER (Brohmer's Fauna Dtschl., ed. 3, p. 370, 1925), type *Hepialus lupulinus* (L.) = *Gazoryctra* HBN. (Verz. bek. Schmett. 13 : 198, 1820), type *G. ganna* (HBN.). Thus the genus *Gazoryctra* HBN. may be divided into the following subgenera:

  (*a*) *Gazoryctra* s. str., type *G. ganna* (HBN.).
  (*b*) *Pharmacis* (HBN. 1820 nec 1823), type *P. carna* (ESP.).
  (*c*) *Korscheltellus* (BÖRNER), type *H. lupulinus* (L.).

(10) *Lamelliformia* VIETTE 1951 b = ? *Cibyra* WALK.
(11) *Osrhoes* DRUCE (Ann. Mag. nat. Hist., (7) 5 : 514, 1900) = ? *Cibyra* WALK.
(12) *Parana* VIETTE 1949 g = *Aepytus* H.-S.
(13) *Paraoxycanus* VIETTE 1950 k = *Oxycanus* WALK.
(14) *Philoenia* KIRBY (Cat. Lep. Heteroc. 1 : 885, 1892; nec *Philaenia*, spelling used by SHARP and others!), type *Pharmacis lagopus* MÖSCHL. = *Aepytus* H.-S.
(15) *Philpottia* VIETTE 1950 k = *Oxycanus* WALK.
(16) *Pseudodalaca* VIETTE 1949 g = *Aepytus* H.-S.
(17) *Pseudophilaenia* VIETTE 1950 c = *Aepytus* H.-S.
(18) *Thiastyx* VIETTE 1951 b = *Roseala* VIETTE.
(19) *Xytrops* VIETTE 1951 b = *Roseala* VIETTE.
(20) *Yleuxas* VIETTE 1951 b = *Aepytus* H.-S.

GENERA NOT BELONGING TO HEPIALIDAE

Casana WALK. (1865), type *C. trochiloides* Walk. = *Cossidae*.
Philanglaus BUTLER (1882), type *P. ornatus* BUTLER = *Cossidae*. Other species: *P. metana* DOGNIN (1910), *P. beatrix* SCHAUS (1921).

NEW ADDITIONAL GENERA

EUDALACINA, gen. n.
Genus novum quod alis anticis nervatione ramis R_4, R_5 breviter pedicellatis a genera *Eudalaca* VIETTE, typo *Epiolus* (*Triodia*) *exul* H.-S., differt. Typus generis: *Hepialus ammon* WALLGR.

RECTIFICATIONS

I. LOSSBERGIANA PSEUDODIMIATA n.sp. (Syn.: *Aepytus dimidiatus* PACLT nec BERG). The genus *Aepytus* H.-S. being now well defined (see VIETTE 1949 g), we may conclude

(i) that the insect described as *Aepytus dimidiatus* ♀ (PACLT 1949) cannot be considered as belonging to that genus,
(ii) that it must be classified as member of the genus *Lossbergiana* VIETTE 1950 c.

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The structural differences after comparison with the original description of *Aepytus dimidiatus* BERG ♂ have been discussed in my paper (PACLT 1949) with the result that they are due to the sexual dimorphism. It is now clear that these are of specific (and generic) importance. Thus the main differences are in the development of palpi labiales, in the structure of antennae and the presence or absence of epiphysis (see the Key). Although similar in habitus, the insect is different from *Aepytus dimidiatus* BERG. (For detailed description of *Lossbergiana pseudodimiata* n.sp., see PACLT 1949 *.)

II. *Hepialiscus* (?) sp.—A very defective specimen of the *Hepialidae* from the N.E. Burma has been reported as ? *Palpifer* sp. by BRYK 1949. It resembles somewhat in the wing pattern with *Hepialiscus kulingi* (DANIEL). For illustration of the latter see DANIEL 1940. The specimen does not possess an epiphysis on front tibiae and the palpi labiales are rather indistinct in it. The venation as well as the antennae are much damaged or missing in the specimen and therefore it is not possible to identify the species with accuracy. Hab.: Kambaiti, 6,000 feet, 5. IV. 1934, leg. Dr. R. Malaise.

III. *Dalaca parviguttata* (BRYK) VIETTE, species bona? VIETTE (1950 e) has tried to show that my synonymy of this species with *Dalaca venosa* (BLANCH.) BERG is inexact and that *D. parviguttata* (BRYK) is a species bona. He has based this interpretation on the study of the genitalia of the respective types, but he forgot, however, that the one specimen is a male, while the other a female. Such a statement seems, therefore, to be less convincing unless more examples are examined.

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* A correction should be made in the diagnosis: 'Antennae and the thorax nearly 10 mm. long' (instead of the version 'Antennae and the thorax of the same length', PACLT 1949, p. 149).

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HYDROBIOLOGICAL CONDITIONS OF THE GANGADHARESWARAR TEMPLE TANK, MADRAS

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Contents

1. Introduction

South India is famous for its numerous temples of architectural beauty. Each of these temples has a perennial tank attached to it. Utilization of these religious institutional waters for pisciculture is now being actively pursued in the Madras State; and therefore the elucidation of the hydrobiology of this type of waters is of practical and economic importance. Besides, as stressed by Thienemann (1926) accurate monographic records of individual waters are necessary not only from the view-point of regional limnology but also for classification of water-types of the world.

Ganapati (1940) made a study of the ecology of a temple tank containing a permanent bloom of *Microcystis aeruginosa*; but he did not make observations on the variations in the hydrobiological conditions of the bottom layer. The present authors have studied the hydrobiological conditions at the surface and bottom of the Gangadhareswarar temple tank in Madras City at fortnightly intervals for a period of one year from April, 1949 to March, 1950. The results of this study form the basis of this paper.

2. Methods

The procedures adopted for the study of the physical and chemical conditions were the same as those described by one of us (S. V. G., 1940). Samples of water were collected both from surface and bottom between 11 a.m. and 1 p.m., the bottom collections being made with the simple deep-sample collector described by Whipple *et al.* (1947). Quantitative analysis of plankton was made by examining and counting the number of organisms in one c.c. of water placed in a counting cell, under the micro-scope using a high power objective (×400).

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3. Physical conditions

(*a*) *Climatic conditions*.—The climatological data of Madras for the period of investigation are furnished in Table I. The conspicuous features of the hot weather period (April and May, 1949 and March, 1950) were high temperature ranging from 69 to 108°F., a moderate rainfall of 10·24 inches and a maximum of 9·94 hours of bright sunshine per day. The south-west monsoon period (June to September) had much fewer hours of bright sunshine, moderately high temperature, and a rainfall of 18·93 inches. Moderate hours of bright sunshine, low temperature and a rainfall of 10·32 inches prevailed during the north-east monsoon season (October to December). Relatively more hours of bright sunshine, low temperature and scanty rainfall were features of the cold weather period (January and February, 1950). The percentage of relative humidity varied little (66·07 to 80·2) during the period of study.

(*b*) *Location, shape, size and depth*.—The tank is situated close to the Gangadhareswarar temple in Puraswalkam, a crowded part of the Madras City; and is used extensively for bathing and washing. It is rectangular in shape with a maximum water-spread of about 27,000 sq. feet; and is enclosed on three sides by a masonry wall and on the fourth side there is an entrance provided with a flight of granite steps. The tank is deeper in the middle and shallower along the margins. The depth varied from 3·5 to 5·0 feet during the period of study. There are no regular inlets and outlets. The tank was at its lowest level on 31st August, 1949.

(*c*) *Colour*.—The colour of water both at the surface and bottom varied from yellowish-green to bright green indicating an abundance of algal growth throughout the year. The colour of the water in the bottom layer did not differ materially from that of the surface.

(*d*) *Turbidity*.—The range of variation in both surface and bottom layers was practically the same, being 3·0 to 19·0, indicating that the amount of algae in suspension was uniform. The water was most transparent in July both in the surface and bottom layers and least in March and April.

(*e*) *Temperature*.—The temperature of the surface layer was at its maximum of 42·8°C. in May; and thereafter declined to its minimum of 28·2°C. in the second half of October. There were slight rises and falls till December. Thereafter there was a rise till the second maximum was reached in the second half of February, 1950. In the case of the bottom layer, which appeared to follow almost closely the variations in the surface layer, the temperature varied from a minimum of 25·6°C. in the first half of December, 1949 to a maximum of 32·8°C. in the second half of February, 1950.

As the temperature of water was recorded between 11 a.m. and 1 p.m. the two graphs run almost parallel except in the second half of October when the two almost meet. The meeting of the two graphs would seem to show that the water was homothermal from the surface to the bottom at noon. In all other months, they do not meet showing thereby that there was a pronounced thermal stratification. The difference between the surface and bottom layers were fairly high in April, May and October, 1949 and in February, 1950. As the temperature of the surface and bottom layers alone were recorded, it is not possible to state whether the three thermal zones of a typical case of stratification were clearly formed in this case. However, the difference between the two maxima for the surface and bottom layers was 10°C., and between their minima 2·6°C. Similar conditions of high temperature difference between surface and bottom have

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been reported to exist during summer months in fish ponds in Southern Jordan Valley (Komarovsky, 1951) and in American ponds by Welch (1935). So, it is not surprising to find a difference of over 10°C. in a shallow tank in the tropics.

Welch (1935) seems to think that the difference between the surface and bottom layers must be great if the thermal stratification should be stable. But Ruttner (1931) has argued that for the same difference in temperature in the tropics, occurring in a lake in the temperature zone, the thermal stratification will be conditioned by a stability two or three times as great as that found in the latter. In the Madras tank also, the thermal stratification was remarkably stable, for the ranges of temperature were 28·2 to 42·8°C. in the surface layer and 25·6 to 32·8°C. in the bottom layer. The maximum difference in temperature of 12·3°C. on 9th May, 1949 thus tended to a difference of 0·0045 gm./c.c. in the density of water between the surface and bottom layers.

4. Chemical conditions

The chemical conditions in the surface and bottom layers of the temple tank on the various dates of study are given in Table II. The seasonal variations of the chemical conditions in the two layers are also indicated in graph I. From a study of this graph and Table II, the following inferences are drawn:—

(*a*) *Dissolved oxygen.*—In the surface layer the amount of dissolved oxygen was found to vary from zero in the second half of August, 1949 to a maximum of 9·14 c.c./l. in the first half of December, 1949. In the bottom layer, it was found to vary from zero in March, April and May to a maximum of 5·37 c.c./l. in the second half of January, 1950. Similar extreme variations in the oxygen content have been shown by Kolkwitz (1914) for the Leitensee in Germany. From the graph it will be seen that (i) the two curves for the surface and bottom layers do not run exactly parallel; (ii) they meet on four occasions, *i.e.*, second half of July, August, October and first half of February. Excepting the second half of August, when the oxygen content in both the layers was zero, on all other occasions, there was some oxygen in both the layers. The factors responsible for creating such uniform conditions at mid-day on those four occasions were found to be artificial. Where the samples were collected the water layers had got mixed together thoroughly from top to bottom. This is confirmed by *p*H, carbon dioxide, carbonates, bicarbonates and organic matter values for both the layers. This mixing was most probably a localized phenomenon as otherwise fish in the pond would have come to the margin gasping for breath. The absence of such a phenomenon indicates that there was no such mixing in all parts of the pond.

Except on the four occasions referred to above there was oxygen stratification. Maximum difference between the two layers was noticed in the first half of December when it amounted to 6·91 c.c./l. The surface layer was supersaturated with oxygen on many occasions. This was to be expected because of the abundance of algal vegetation and the comparatively longer hours of bright sunshine.

(*b*) *Free carbon dioxide, carbonates and bicarbonates.*—Free CO_2 was absent in the surface layer, except on the four occasions when amounts varying between 0·160 and 0·530 parts per 100,000 were present. In the bottom layer, it varied from zero to 0·570 parts per 100,000 almost throughout the year. The carbonates varied from zero to 6·56 parts per 100,000 in the surface layer and from zero to 0·89 parts per 100,000 in the bottom

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layer. The maximum amount in the surface and bottom layers was found in the first half of May, 1949 and in the second half of January, 1950 respectively. The bicarbonates in the surface layer varied from a minimum of 3·93 parts per 100,000 in the second half of May, 1949 to a maximum of 18·86 parts per 100,000 in the second half of October, 1949; and in the bottom layer from a minimum of 7·03 parts per 100,000 in the second half of January, 1950 to a maximum of 20·3 parts per 100,000 in the first half of May, 1949. The bicarbonates were uniform at both the surface and bottom layers on three occasions, namely, second half of July, 1949, second half of August, 1949 and second half of January, 1950. As already described, the uniformity on those occasions was due to the artificial mixing of the tank water in the spot where the samples were collected.

(c) *pH.*—In the surface layer, the *p*H values varied from a minimum of 6·9 in the second half of August to 9·6 in the first half of May; and in the bottom layer, they varied from a minimum of 6·8 in the second half of August to 8·6 in the second half of June. The *p*H values for the two layers were the same on the four occasions, when the dissolved oxygen was uniform. Any *p*H value over 8·1 would indicate that photosynthesis exceeds respiration and may be taken to denote approximate saturation with oxygen, higher values often accompanying supersaturation (Atkins and Harris, 1924).

(d) *Oxidisable organic matter.*—In the surface layer, it was found to vary from a minimum of 1·76 parts per 100,000 in the second half of May and June to a maximum of 2·14 parts per 100,000 in the second half of October. In the bottom layer, it was found to vary from a minimum of 1·44 parts per 100,000 in the second half of May to 2·22 parts per 100,000 in the first half of October.

(e) *Chlorides.*—In the surface and bottom layers, the amount was almost the same and varied from a minimum of 4·0 parts per 100,000 in the first half of June to a maximum of 16·8 parts per 100,000 in the second half of August.

(f) *Nitrates.*—Nitrates were not detected at any time in both the layers.

(g) *Phosphates* (P_2O_5).—They were found in larger amounts in the bottom layer than in the surface layer; but varied from 'traces' to 0·38 parts per 100,000. As the graph shows phosphates were present almost throughout the year in both the layers with a maximum during the hot weather and a minimum during the cold weather.

(h) *Silicates* (SiO_2).—Silicates though present almost throughout the year in both the layers were also found to be greater at the bottom layer than at the surface. During the south-west and north-west monsoons, silicates were comparatively low in both the layers.

5. Biological conditions

A few zooplanktonic organisms like the copepods, *Mesocyclops* and *Neodiaptomus*, were met with in all the collections, but were very insignificant as compared with the phytoplankters which were represented by the following :—

(i) *Chlorophyceae*: *Ankistrodesmus* was abundant on one occasion only. *Pediastrum* was found in smaller numbers in July and September, 1949, while *Scenedesmus* was noticed in slightly greater numbers on five different occasions. This assemblage of green algae, according to Pearsall (1923) must be regarded as typical of a warm calcareous lake moderately rich in available nitrogen.

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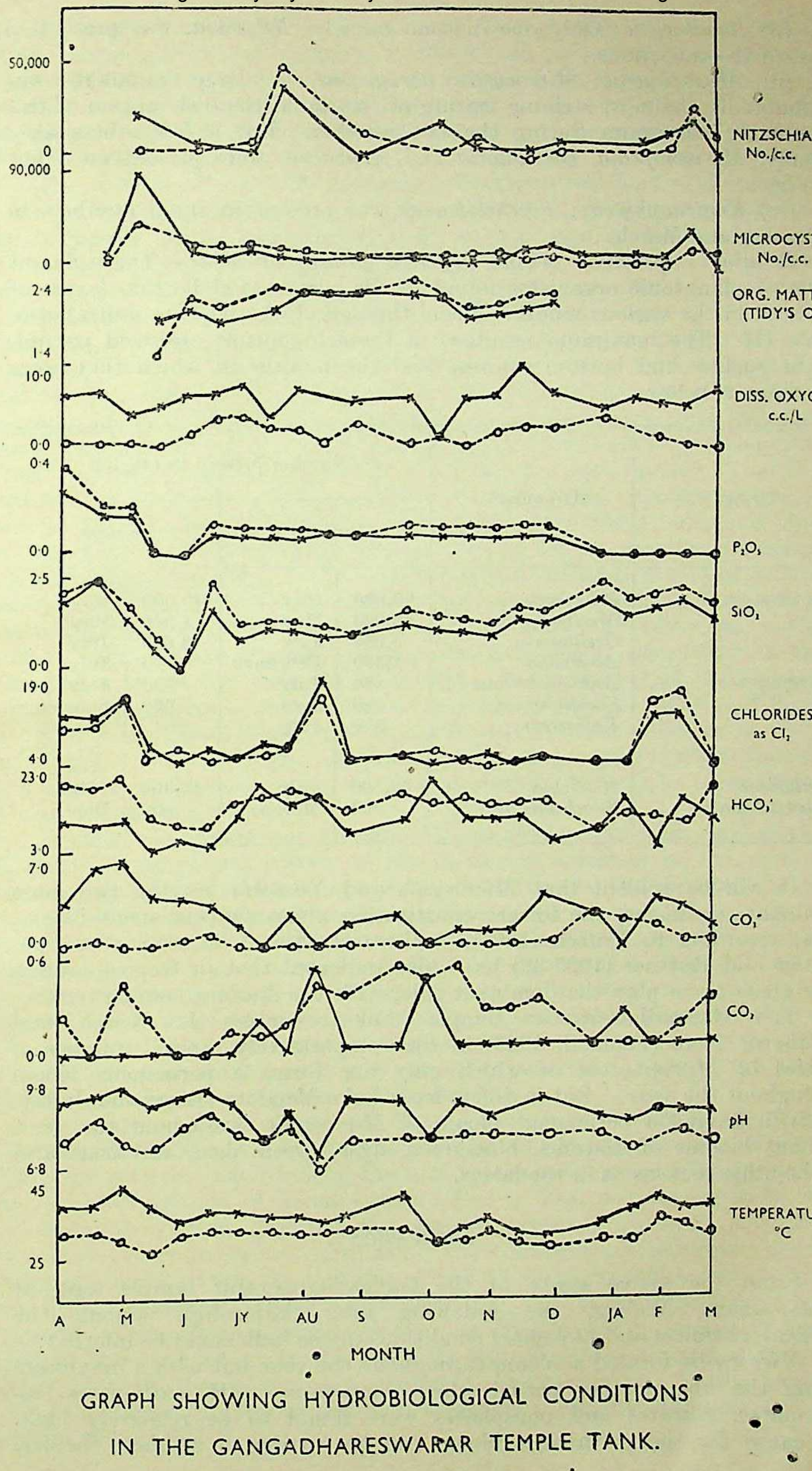

GRAPH SHOWING HYDROBIOLOGICAL CONDITIONS IN THE GANGADHARESWARAR TEMPLE TANK.

SURFACE BOTTOM

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(ii) *Bacillarieae*: Only one diatom, namely, *Nitzschia*, was present in most of the collections.

(iii) *Myxophyceae*: *Microcystis aeruginosa* in large numbers was undoubtedly the most striking feature of this tank, the distribution of this alga being maximum during the hot weather. But a few others also, namely, *Merismopedia*, *Oscillatoria* and *Anabaena*, were present on a few occasions.

(iv) *Euglenophyceae*: *Trachelomonas* was present in small numbers in December and March.

Relative importance of the different groups of algae.—The different kinds of planktonic organisms found in the surface and bottom layers of the tank in the various months during the period of study are indicated in Table III. The maximum numbers of these organisms observed per ml. at the surface and bottom samples and the months in which they were noted are as below.

Group	Organism	Number present in one ml.			
		Surface		Bottom	
Myxophyceae ..	*Microcystis* ..	90,000	May	40,000	May
	Merismopedia ..	40,000	May	1,000	May
	Oscillatoria ..	2,250	July	3,600	July
	Anabaena ..	1,350	February	570	July
Chlorophyceae ..	*Ankistrodesmus* ..	180	July	930	July
	Scenedesmus ..	900	July	900	February
	Pediastrum ..	570	July	*Nil*	Throughout the year.
Bacillarieae ..	*Nitzschia* ..	38,700	July	45,900	July
Euglenophyceae ..	*Trachelomonas* ..	900	March	900	March

It will be evident that *Microcystis* and *Nitzschia* are the two most dominant organisms, the former constituting almost a permanent bloom. This, according to Fritsch (1907), is characteristic of all tropical waters. Geitler and Ruttner (1935-36) have also indicated that in tropical waters blue-green algae play the dominant rôle, with the diatoms coming next.

The Gangadhareswarar temple tank resembles L. Neagh and Rostherne Mere (Pearsall, 1923) in the comparatively limited number of species of *Myxophyceae* of which only one forms a permanent bloom throughout the year. But it differs from Lake Mendota (Birge and Juday, 1922) in having a permanent bloom of *Microcystis* throughout the year, without blooms of diatoms, blue-green algae, green algae and flagellates in the other seasons as in the latter.

6. Discussion

From the above study of the Gangadhareswarar temple tank at Puraswalkam, Madras, the following inter-relationships among the physical, chemical and biological conditions in the tank could be inferred:—

Microcystis formed a bloom throughout the year but with a maximum during the hot weather period when temperature, *p*H, carbonates, bicarbonates, silicates and phosphates were found to be relatively high. The cause for the permanent bloom can be attributed to three factors,

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namely, warmth, sunshine and nutrient substances (excepting nitrates) being always present in optimum. During the period of study temperature in the surface and bottom layers ranged from 25·6 to 42·8°C., and sunshine from 5·03 to 9·94 hours a day over a whole month. Excepting the nitrates all the dissolved mineral substances necessary for life were always found in abundance.

The question is how in the absence of nitrates a rich flora of *Microcystis* is continuously maintained in the tank. This rich organic matter, according to Pearsall (1923), will rapidly absorb oxygen resulting in the liberation of carbon dioxide and available nitrogen. Cooper (1933) has noted that ammoniacal nitrogen can also be utilized by phytoplankton. Harvey (1940) observed that communities of diatoms could use all ammonia directly. Harold (1934) also found a marked reduction in nitrites and nitrates in cases of abnormal algal development. So it is quite probable that the algal flora in the tank uses the ammoniacal nitrogen very rapidly as soon as it is formed so that there is neither time nor sufficient free ammonia left, for its conversion into nitrites and nitrates. Ganapati (1949 and 1941) explained the absence of nitrites and nitrates in similar tanks as follows: 'They are probably utilized during photosynthesis as soon as they are formed daily, leaving practically nothing behind or they are acted upon by denitrifying bacteria which are very active at higher temperatures (Pia, 1934)'. But Atkins (1933) believes that the second reason is not so satisfactory as the first in view of the fact that denitrifying bacteria do not act in the presence of an abundant supply of oxygen in the surface waters of the tropics. In any case the absence of nitrates in the tank water is not the only one on record. Hutchinson *et al.* (1932) have reported mere traces or total absence of nitrates in all the ponds and lakes of South Africa; and Beadle (1934) has found the same thing in the Rift Valley lakes of East Africa. Kolkwitz (1914) also recorded their absence in Leitensee in Germany under conditions almost identical to those found in the present tank water.

Further, the permanent bloom of *Microcystis* in the tank implies the existence in large proportions of the dissolved nutrients in the surface layers of the tank throughout the year. According to Worthington (1943) tropical waters are generally more productive on account of the higher water temperature and lack of a winter season. The temperature of the bottom layer of water is relatively high as compared to the temperate region, and so the bacterial decomposition of the bottom deposits in tropical ponds must release large amounts of nutrient substances. These are carried to the surface probably by a phenomenon of diurnal thermal stratification and diurnal turn over, so that the surface layer of the tank water is always rich in nutrient substances.

Not only is *Microcystis* found to be a permanent bloom in the tank, but also forms the dominant organism in almost all seasons. Fritsch (1907) refers to the dominance of the blue-greens in the tropics being due to the deficient aeration of warm waters. But it does not appear to be so, for especially during daytime the surface layer of the tank is supersaturated with oxygen. Further, the maximum phytoplanktonic organisms occur in the hot weather period when temperature and oxygen are high. Pearsall's (1923) explanation for the development of large numbers of the Cyanophycean element in Rosthernmere seems to hold good in this case also. In his pond the blue-greens developed a partial bloom when the temperature and organic matter were high. In the temple tank, the bloom of *Microcystis* was permanent and independent of the amount of rainfall.

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Besides *Microcystis* (*Myxophyceae*), the tank contains *Nitzschia* (*Bacillariae*) and *Trachelomonas* (*Euglenophyceae*) in fair proportions as in the typical eutrophic lake described by Welch (1935). Even though nitrates are absent, this tank water is rich in other dissolved nutrient materials like phosphates, silicates and organic matter. So, the Gangadhareswarar temple tank may also be described as eutrophic in character and may be expected to be highly productive. This is actually so judging from the yield of over a 1,000 lbs. of fish a year. Fishes like *Catla catla*, *Cirrhina mrigala*, *Labeo fimbriatus*, *Cyprinus carpio* and *Chanos chanos* have shown remarkable growth in similar temple tanks. Fingerlings of *Catla*, 2 to 3 inches in size, have attained a length of 27 inches and a weight of 7 lbs. in the first year in the Sree Meenakshi temple tank in Madurai (Chacko, 1949); and *Chanos*, 2 inches long attained a length of 25 inches and a weight of 2 lbs. in one year in the Rameswaram temple tank (Chidambaram and Unni, 1946). The Gourami (*Osphronemus gourami*) and the Pearl-spot (*Etroplus suratensis*) have bred and multiplied in many similar types of waters. From a comparative study of inland waters in the Madras State, Ganapati and Chacko (1950) have found that tanks under the control of religious institutions containing blooms of one or more species of algae are the most productive waters, yielding over 2,000 lbs. of fish per acre per year. The main cause for the high productivity of these temple tanks is probably due to the continued existence of high proportions of dissolved nutrient materials and the high reserve alkalinity of their water. For example, the reserve alkalinity of the tank water studied was of the order of 250 mg./litre, which according to Ellis (1937) is the best medium for fish growth. Also, according to Hubbs and Eschmeyer (1938) hard waters are generally more productive than soft waters. Further, Swingle and Smith (1947) have stated that a high production can be obtained if the fish stocked is primarily a phytoplankton feeder. The Gangadhareswarar temple tank contained a permanent bloom of *Microcystis* and the *Catla catla*, *Labeo fimbriatus*, *Chanos chanos* and *Etroplus suratensis* stocked in it were mainly phytoplankton feeders.

Tanks like that of the Gangadhareswarar temple seem to have physical, chemical and biological conditions favourable for the formation of a permanent bloom of one or more species of algae, yielding a high weight of fish if stocked with a suitable number of phytoplankton feeders. But this algal bloom should not be allowed to form a dense scum on the surface of the tank as such a state would tend to cause fish mortality in the tank. The present authors (Ganapati *et al.*, 1950) have reported mortality of this kind in the moat fish farm of Vellore Fort. Similar instances of mortality of fish have also been recorded in the South Jordan Valley (Komarovsky, 1951). In this connection it is interesting to note that Shelubsky (1951) has reported *Microcystis* spp. to be toxic not only to fish but also to white mice, white rats, and frogs into which these algal suspensions had been subcutaneously and intraperitoneally injected.

7. Summary

The physical, chemical and biological conditions of the surface and bottom waters of the Gangadhareswarar temple tank in Madras City were studied at fortnightly intervals for a period of one year from April, 1949 to March, 1950. *Microcystis* formed a permanent bloom in this tank throughout the year, the other dominant organism being *Nitzschia*. The cause for the permanent bloom could be traced to diurnal thermal stratification and diurnal turn-over, which was responsible for the large proportions of the

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dissolved nutrients all through the year. The nitrates were absent probably because the ammonical nitrogen produced were very rapidly consumed by the algal flora of the tank as soon as they were formed, leaving nothing for conversion into nitrites and nitrates, other dissolved nutrients and the reserve alkalinity were the optimum. The productivity in the tank is higher than in a pond without a permanent algal bloom.

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TABLE I

Showing the climatological data of Madras from April, 1949 to March, 1950

Month	Temperature (°F.)				Percentage of relative humidity		Total rainfall in inches	No. of hours of bright sunshine per day
	Maximum		Minimum					
	Range of variation	Average	Range of variation	Average	Range of variation	Average		
April, 1949 ..	90–108	96·13	77–84	80·20	36–87	69·43	0·91	9·94
May, ,, ..	79–105	96·77	75–85	81·70	51–95	66·51	8·95	7·99
June, ,, ..	91–101	95·90	73–83	78·93	51–85	66·07	3·99	7·21
July, ,, ..	88–96	92·96	73–79	77·40	59–87	71·74	2·99	5·78
August, ,, ..	88–96	92·50	73–81	77·30	57–92	77·50	5·21	5·80
September, ,, ..	84–94	90·70	73–81	77·03	59–94	75·43	6·74	5·03
October, ,, ..	83–97	91·29	74–80	76·90	59–96	77·67	3·35	7·51
November, ,, ..	75–89	85·20	66–78	71·40	63–97	80·20	6·93	8·85
December, ,, ..	82–85	83·70	62–73	67·60	63–91	77·80	0·04	9·53
January, 1950 ..	80–81	80·40	60–70	65·40	46–90	77·60	0·06	9·66
February, ,, ..	80–91	83·70	60–70	67·30	47–89	76·10	0·17	9·90
March, ,, ..	85–96	90·80	69–80	74·50	65–85	73·00	0·38	9·93

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Table II

Showing the fortnightly variation of the Physico-chemical conditions of the Gangadhareswarar Temple tank, Purasawalkam, Madras, during 1949-1950

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Date of collection	Time of collection	Temperature (°C.)		Transparency cms.		Dissolved O_2 (c.c./lit.)		Free CO_2 p.p. 100,000		Carbonates p.p. 100,000		Bicarbonates p.p. 100,000		pH		Chlorides as Cl p.p. 100,000		Silicates (SiO_2) p.p. 100,000		Phosphates (P_2O_5) p.p. 100,000.		Nitrates (N) p.p. 100,000		Tidy's O_2 organic matter	
		S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.
9- 4-49	1-00 p.m.	37·8	31·8	12·0	9·0	5·79	0·07	Nil	0·27	3·42	Nil	10.44	17·99	9·1	7·8	11·0	10·0	2·14	2·17	0·26	0·38	Nil	Nil	..	..
22- 4-49	2-20 ,,	38·2	32·0	5·0	3·0	5·86	Nil	Nil	Nil	5·99	0·57	8·99	17·70	9·2	8·5	11·0	11·0	2·50	2·50	0·18	0·21	Nil	Nil	..	..
9- 5-49	1-15 ,,	42·8	30·5	13·0	6·0	3·14	0·21	Nil	0·47	6·56	Nil	10·73	20·31	9·6	7·8	15·0	15·0	1·47	1·64	0·163	0·165	Nil	Nil	..	..
23- 5-49	1-35 ,,	37·2	27·8	5·0	3·0	4·12	Nil	Nil	0·23	3·87	Nil	3·93	10·58	8·9	7·4	6·0	5·0	0·77	0·802	Tr.	Tr.	Nil	Nil	1·76	1·44
6- 6-49	12-30 ,,	34·0	31·1	8·6	8·2	5·17	1·12	Nil	Nil	3·57	0·30	6·30	9·61	9·2	8·0	4·0	5·0	Tr.	Tr.	Tr.	Tr.	Nil	Nil	1·92	2·00
21- 6-49	12-30 ,,	36·8	32·6	14·5	14·1	5·79	2·79	Nil	Nil	2·97	0 89	4·80	9·31	9·4	8·6	6·0	5·0	1·70	2·40	0·1	0·10	Nil	Nil	1·76	1·92
4- 7-49	11-35 a.m.	36·6	30·9	19·0	18·0	6·98	3·28	Nil	0·14	1·50	Nil	10·07	13·70	9·0	7·95	5·0	5·0	0·88	1·20	0·097	0·10	Nil	Nil	..	..
18- 7-49	11-00 ,,	34·8	31·8	..	..	2·86	2·51	0·16	0 13	Nil	Nil	16·83	16·64	7·9	7·9	7·0	6·0	1·20	1·24	0·093	0·10	Nil	Nil	1·88	2·14
16- 8-49	11-40 ,,	34·8	30·6	10·4	9·2	6·63	1·95	Nil	0·14	2·57	Nil	13·93	15·67	8·6	7·9	7·0	7·0	1·20	1·22	0·081	0·088	Nil	Nil	2·10	2·30
31- 8-49	11-00 ,,	30·6	29·9	10·0	8·0	Nil	Nil	0·53	0·51	Nil	Nil	15·25	15·25	6·9	6·8	16·8	16·2	1·00	1·20	0·085	0·081	Nil	Nil	2·10	2·10
14- 9-49	12 Noon	34·8	31·0	8·6	8·4	5·38	2·65	Nil	0·31	1·52	Nil	7·42	11·75	9·0	7·6	5·0	4·0	1·00	1·00	0·086	0·081	Nil	Nil	2·06	2·10
10-10-49	12-45 p.m.	37·4	30·8	9·2	4·9	5·79	0·49	Nil	0·54	2·13	Nil	10·15	16·08	9·0	7·8	5·0	5·0	1·40	1·64	0·092	0·094	Nil	Nil	2·14	2·22
26-10-49	11-30 a.m.	28·2	27·8	5·0	5·3	1·54	1·47	0·47	0·45	Nil	Nil	18·86	14·22	7·7	7·7	4·0	4·0	1·20	1·52	0·083	0·090	Nil	Nil	1·98	2·02
8-11-49	12 Noon	29·8	28·0	6·2	5·3	5·10	0·14	Nil	0·57	1·22	Nil	11·13	15·46	8·8	..	4·0	4·0	1·20	1·40	0·085	0·089	Nil	Nil	1·78	1·84
29-11-49	12-30 p.m.	31·2	30·0	..	..	5·72	1·60	Nil	0·23	0·91	Nil	10·82	12·37	8·4	7·8	5·0	5·0	1·08	1·24	0·080	0·083	Nil	Nil	1·86	1·94
13-12-49	12 Noon	28·4	25·6	..	..	9·14	2·23	Nil	0·23	1·20	Nil	11·30	13·44	8·6	7·8	4·6	4·4	1·60	1·72	0·095	0·11	Nil	Nil	1·94	2·00
27-12-49	12-35 p.m.	28·2	25·9	..	..	6·56	2·09	Nil	0·27	3·61	Nil	5·81	13·75	9·0	7·8	5·0	5·0	1·44	1·60	0·089	0·10	Nil	Nil	2·02	2·06
28- 1-50	11-30 a.m.	30·8	28·7	6·5	6·0	4·26	3·50	Nil	Nil	2·40	2·40	7·63	7·63	8·4	8·6	4·3	4·13	2·14	2·50	Nil	Nil	Nil	Nil	..	..
8- 2-50	1-30 p.m.	33·4	27·6	7·0	6·0	5·10	5·00	Nil	0·22	1·80	Nil	14·34	11·29	8·2	7·3	4·1	3·7	1·50	2·0	Nil	Nil	Nil	Nil	..	..
24- 2-50	11-00 a.m.	36·2	32·8	6·2	5·75	4·82	1·26	Nil	Nil	3·30	1·80	6·71	10·68	8·6	8·6	12·0	13·0	2·00	2·0	Nil	Nil	Nil	Nil	..	..
8- 3-50	11-30 ,,	33·1	31·2	..	6·0	4·65	0·39	Nil	0·11	3·00	Nil	14·03	10·07	8·6	7·8	12·0	15·0	2·22	2·14	Nil	Nil	Nil	Nil	..	..
22- 3-50	11-30 ,,	34·2	30·1	3·5	3·25	6·00	Nil	Nil	0·33	1·50	Nil	12·20	10·47	8·5	7·2	4·0	4·0	1·50	1·88	Nil	Nil	Nil	Nil	..	..

S = Surface.
B = Bottom.

Table III

Showing the number of the Planktonic Organisms per ml. in the Gangadhareswarar Temple tank, 1949-1950

			Microcystis		Merismopedia		Oscillatoria		Anabaena		Ankistrodesmus		Pediastrum		Scenedesmus		Nitzschia		Trachelomonas	
			S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.
April,	1949	2nd half ..	10,000	6,400	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
May,	,,	1st ,, ..	90,000	40,000	40,000	1,000	..	..	Nil	500	..	..	..	..	..	..	20,000	Nil	..	..
June,	,,	1st ,, ..	9,000	13,500	..	..	..	..	..	..	..	..	..	..	..	..	4,500	4,000	..	..
June,	,,	2nd ,, ..	4,500	13,500	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
July,	,,	1st ,, ..	9,570	11,250	..	..	..	..	Nil	570	80	930	570	Nil	..	..	Nil	2,250	..	..
		2nd ,, ..	7,650	9,000	..	..	2,250	3,360	..	..	..	..	..	..	900	Nil	38,700	45,900	..	..
August,	,,	1st ,, ..	6,400	7,200	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
September,	,,	1st ,, ..	5,400	5,400	..	..	..	..	..	..	..	..	450	Nil	..	..	Nil	11,700	..	..
October,	,,	1st ,, ..	6,000	7,000	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		2nd ,, ..	6,300	7,850	..	..	..	..	..	..	..	..	..	..	Nil	450	15,750	Nil	..	..
November,	,,	1st ,, ..	6,300	9,000	..	..	..	..	..	..	..	..	..	..	..	..	5,400	9,450	..	..
		2nd ,, ..	9,000	11,700	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December,	,,	1st ,, ..	10,800	9,450	..	..	..	..	..	..	..	..	..	..	450	Nil	1,350	450	450	Nil
		2nd ,, ..	17,550	17,100	..	..	..	..	..	..	..	..	..	..	..	..	9,450	3,150	..	..
January,	1950	1st ,, ..	8,900	5,100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February,	,,	1st ,, ..	13,950	10,350	..	..	..	..	1,350	Nil	..	..	..	..	450	900	9,900	2,700	..	..
	,,	2nd ,, ..	11,700	7,650	..	..	..	..	450	450	..	..	..	..	..	..	12,600	4,450	..	..
March,	,,	1st ,, ..	36,900	23,850	..	..	..	..	..	..	..	..	..	..	Nil	450	24,300	26,550	900	900
		2nd ,, ..	5,400	10,800	..	..	..	..	..	..	..	..	..	..	..	..	1,350	4,500	450	Nil

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S = Surface.

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FERNS OF ASSAM

By P. Kachroo

(*Paper received on October 28th, 1952*)

Assam is situated in the north-eastern corner of India and its climate is characterized by heavy rainfall during summer and spring, a warm summer and a cool winter. Khasi and Jaintia Hills receive the highest rainfall and Manipur the lowest. Topographically the State is divided into five regions as follows:—

(i) The Aka, Abor, Mishmi and surrounding Hills.
(ii) The Brahamputra Valley.
(iii) The Garo, Khasi and Jaintia, Cachar and Mikir Hills.
(iv) The Surma Valley.
(v) The Naga Hills, Manipur and Lushai Hills.

Being situated at the north-eastern corner of Indian Himalayas, north-western end of Burma and Malayan Peninsula and at the junction of Tibet and south-eastern China it has provided a meeting place of the flora of these regions as also a highway for the southward drift of many Indo-Chinese or northern species. The flora on the whole shows predominance of northern element. The most predominant genera are *Polypodium*, *Asplenium*, *Pteris*, *Dryopteris*, *Pyrrosia* and *Davallia* respectively.

Of the 21 families listed by Copeland (1947) 18 are represented in this region with 69 genera and 180 species. The poor representation of the species is due to lack of comprehensive collection since there is no extensive record of ferns of Assam. All the early workers seem to have concerned themselves mainly with phanerogams and made sultry references to cryptogams which are so abundant in Assam.

Ferns have in the past been divided on the nature of the annulus, those with a vertical annulus being included in Polypodiaceae and the rest segregated into 15 orders. Whereas there is general agreement in arrangement of the latter the former have provided a residual group for dumping of forms which long justified separate entity. Consequently the group has been divided by Diels (1902), Bower (1928), Christensen (1938), Ching (1940), Copeland (1947) and Holttum (1949) into different families, sub-families or tribes. Dickason (1946) and Stokey (1951) give a comparative account of the same.

This work does not attempt to give any phylogenetic classification but a partly artificial key is proposed for identification of ferns of Assam. Genera are grouped according to their habit. In each group attention is paid mainly to nature and character of sori—induciate or not, sporangia—free or in sporangiophores, etc. Besides the most salient feature of each genus is included. It is based on a collection of ferns mostly from Khasi and Jaintia Hills and the plains of Gauhati. A detailed investigation on the taxonomy of ferns is in progress.

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KEY TO THE GENERA

- Aquatic ferns.
  - Sporangia in sporocarps. Spores of two kinds.
    - Leaves 4 clover-like .. .. 67. Marsilea.
    - Leaves in 3 whorls—2 dorsal floating and 3rd submersed and root-like .. .. 68. Salvinia.
    - Leaves minute and closely placed .. 69. Azolla.
  - Sporangia protected by reflexed margin which meets at the midrib.
    - Fertile segment narrow, leaves large, pinnatifid (often rooted in mud) .. .. 25. Ceratopteris.
- Climbing ferns.
  - Sporangia in spikes on marginal lobes of pinnae, each sporangium within a scaly inducium, veins free .. .. .. 6. Lygodium.
  - Sporangia covering the pinna from costa to margin, fronds dimorphic, fertile linear, entire, veins parallel .. .. .. 47. Stenochlaena.
- Terrestrial or epiphytic.
  - Sporangia or sporangiophores. Terrestrial.
    - Sporangiophores arising from the base or apex of the sterile part of the leaf blade.
      - Leaves simple .. .. .. 1. Ophioglossum.
      - Leaves palmately compound .. 2. Helminthostachys.
      - Leaves pinnate-fidly compound .. 3. Botrychium.
  - Sporangia in sori.
    - Sori continuous.
      - At or near the margin.
        - Protected by revolute margin.
          - Annulus oblique and not interrupted by pedicel .. .. .. 31. Plagiogyria.
        - Protected by reflexed margin.
          - Marginal flap opening away from the margin.
            - Dictyostelic, fronds pinnate to compound .. .. 18. Pteris.
            - Solenostelic.
              - Fronds pedate .. .. 17. Histiopteris.
              - Fronds pinnately compound, inducium double .. .. 16. Pteridium.
              - Fronds tri-pinnate-compound. Marginal flaps meeting at costa. Sori from margin to midrib .. 21. Onychium.
          - Petioles dark polished.
            - Leaflets pinnatifid and usually with white powder on upper surface .. .. 20. Cheilanthes.
            - Sori on inside of reflexed margin. Fronds pinnately compound .. 24. Adiantum.

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Margin not reflexed.		
Rhizome protostelic.		
Pinnules dimidiate ..	12.	Lindsaea.
Pinnules cuneiform ..	13.	Sphenomeris.
Rhizome solenostelic, fronds simple	14.	Schizoloma.
Exinduciate.		
Epiphytic.		
Parallel to margin. Sporangia with paraphysis. Fronds linear, hairy	66.	Vittaria.
Marginal. Stellate paraphysis. Fronds dimorphic, fertile linear-elliptic	55.	Pteropsis.
Terrestrial.		
Large, erect. Pinnate, fertile pinnae linear with neither surface covered with sporangia ..	45.	Brainea.
Induciate.		
Terrestrial.		
Sori infra-marginal. Inducium half cup shaped	10.	Microlepia.
Near to costa. Inducium opening towards the costa	44.	Blechnum.
Between margin and costa. Leaves dimorphic, fertile grass-like ..	44.	(Lomaria).
Sori not continuous. Inducium opening along the costule	46.	Woodwardia.
Sori elongate.		
Oblique to costa.		
Induciate.		
Sori along the veinlets, single ..	48.	Asplenium.
Sporangia borne along the veins.		
Exinduciate.		
Veins anastomosing.		
Rhizome solenostelic. Fronds simple-pinnate. Paraphysis present	15.	Syngramme.
Epiphytic, dictyostelic, fronds simple	64.	Loxogramme.
Veins free. Rhizome dictyostelic.		
Margins usually sterile. Spores bilateral, smooth, pale ..	19.	Coniogramma.
Spores globose-tetrahedral, reticulate-spinose	22.	Gymnopteris.
Sori roundish.		
Exinduciate.		
Sporangia in sorus developing simultaneously. Oblique transverse an-		

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nulus. Large pseudodichotomous pinnate-compound fronds ..	7.	Gleichenia.
Sporangia mixed with glandular trichomes. Fronds clustered, lamina pinnate	12.	Monochosorum.
Fronds articulate to rhizome.		
Sori close together on either side of costa. Leaves simple bearing stellate hairs. Epiphytic ..	55.	Pyrrosia.
Sori in a row along the costa or along lateral veins. Spores smooth ..	52.	Pleopeltis.
Rhizome solenostelic. Lamina cut to base into two parts. Stomium ill-developed	49.	Dipteris.
Rhizome dictyostelic.		
Fronds simple-compound. Paraphysis usually present. Spores hyaline, tuberculate	51.	Polypodium.
Fronds imparipinnate. Lateral pinnae articulate to rachis. Spores brownish	63.	Arthromeris.
Fronds simple-pinnatifid. Sori usually compital	56.	Microsorium.
Fronds pedatisect. Sori close to or parallel to costae near the base. Paraphysis present. Spores smooth	53.	Neocheiropteris.
Fronds dimorphic. Epiphytic.		
Small. Margin of pinnae notched.		
Sori in one row on each side of costa, one between each pair of veins ..	62.	Crypsinus.
Humus collecting habit. Large.		
Base of leaf humus collecting. Lamina pinnatisect. Sori in one row between each pair of main veins	60.	Pseudodrynaria.
Dry persistent scale leaf humus collecting. Vegetative leaves dimorphic, pinnatisect, lobes articulate to rachis	61.	Drynaria.
Sori oblique to axis. Fronds herbaceous, simple, pinnate. (Often coenosori)	58.	Colysis.
Induciate.		
Stipes articulate.		
Inducium pocket shaped. Spores oblong-reniform.		
Fixed by base and sides. Spores smooth	27.	Davallia.
Large, pale, fixed by base (or by sides). Spores tuberculate ..	26.	Leucostegia.

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Stipes not articulate.

Inducium fixed by base, circular. Spores bilateral .. .. 30. Nephrolepis.

Inducium globose opening at top (or absent).

Annulus oblique and not interrupted by pedicel. Tree fern .. .. 32. Cyathea.

Inducium globose opening irregularly..

Fronds 4-pinnate. Epispore coarsely ribbed .. .. .. 33. Diacalpe.

Fronds 3-4 pinnate. Sori stalked. Epispore smooth .. .. 34. Peranema.

Inducium reniform (or round-reniform).

Fixed by sinus.

Fronds dimorphic.

Simple. Fertile linear with sori in one row on each side of costa (or simple pinnatifid), articulate 29. Oleandra.

Sori usually submarginal .. 28. Humata.

Lamina bi-pinnatifid.

Often scaly, costae decurrent .. 38. Dryopteris.

Lamina scaly and hairy .. 39. Ctenitis.

Lamina hairy, entire. Veins anastomosing .. 41. Lastrea.

Lamina deeply cut. Veins free 42. Cyclosorus.

Inducium peltate (or absent).

Lamina simple-decompound, hairy 40. Tectaria.

Lamina pinnate—compound .. 35. Polystichum.

Inducium circular or naked.

Elongate along the veins .. 43. Athyrium.

Annulus oblique. Filmy ferns.

Fronds pinnately compound. Margin toothed. Inducium bilipped .. 8. Hymenophyllum.

Fronds uniform-pinnatifid. Inducium cuplike .. .. 9. Trichomanes.

Sporangia not in sori.

In synangia.

Near the margin, elongate along the veins in double rows. Fronds stipulate. Huge fern .. .. 4. Angiopteris.

Covering the undersurface of fertile leaf.

Rhizome short creeping.

Leaves lanceolate .. .. 37. Elaphoglossum.

Rhizome ascending. Sporangia all along veins. Spores dark .. .. 23. Pityrogramma.

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Fronds dimorphic.
Dictyostelic.
Paraphysis absent.
Small. Epiphytic. Stipes articulate .. .. .. 57. Leptochilus.
Terrestrial, stipe not articulate.
Veins forked, free; fertile frond contracted .. .. 36. Egenolfia.
Veins reticulate, fertile frond linear-filiform .. .. 59. Dendroglossa.
Paraphysis present.
Large epiphyte. A specialized part of normal frond sporangiferous. Scale (frond) dry, brown, persistent.. .. .. 49. Platycerium.
Pinnate. Veins free.
Compound (or pinnate dimorphic), *stipulate,* fertile without pinnae. Sporangia open by vertical slit .. 5. Osmunda.

Enumeration and Distribution of Species *

Ophioglossaceae

1. *Ophioglossum* L.

O. pedunculosum Desv. .. Shillong.
O. vulgatum L. .. .. Aka Hills, Abor Hills.

2. *Botrychium* Swartz.

B. virginianum Sw. .. .. Khasi Hills (Elephant Falls, Happy Valley, Mawphlang).

3. *Helminthostachys* Kaulfuss.

H. zeylanica (L.) Hk. .. .. Gauhati (Kalapahar), Sibsagar, Abor Hills.

Marattiaceae

4. *Angiopteris* Hoffmann.

A. evecta (Forster) Hoffm. .. Gauhati (Chandmari, Kamakhya), Khasi Hills (Barapani, Umteswar, Lawlyndoh), Gogwa Forest, Abor Hills, Sibsagar-Dibrugarh Road.

* The arrangement of families and genera is after Copeland (1947) and the species are arranged alphabetically.

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OSMUNDACEAE

5. *Osmunda* L.

O. regalis L. .. .. Khasi Hills (Shillong, Mawphlang).

SCHIZEACEAE

6. *Lygodium* Swartz.

L. flexuosum (L.) Sw. .. .. Gauhati, Khasi Hills (Shillong, Dawki, Mawphlang), Aka Hills.
L. japonicum (Thbg.) Sw. .. Naga and Abor Hills.

GLEICHENIACEAE

7. *Gleichenia* Smith.

G. linearis C. B. Clarke .. Throughout Khasi and Jaintia Hills, Jorhat, Aka and Abor Hills.

HYMENOPHYLLACEAE

8. *Hymenophyllum* Smith.

H. australe Willd. .. .. Aka and Abor Hills.
H. exsertum Poir. .. .. Khasi Hills (Elephant Falls, Dawki)
H. felicula Bary .. .. Elephant Falls.
H. javanicum Spr. .. .. Khasi Hills (Elephant Falls).

9. *Trichomanes* L.

T. bipunctatum Poir. .. .. Aka and Abor Hills, Shillong.
T. bilabiatum Nees and Bl. .. Abor Hills.

PTERIDACEAE

10. *Microlepia* Presl.

M. hirta (Klf.) Presl. .. .. Aka and Abor Hills.
M. marginata C. Chr. .. .. Abor Hills.
M. speluncae (L.) Moore. .. Khasi Hills (Dawki).

11. *Monachosorum* Kunze.

M. subdigitatum Kuhn. .. Abor Hills.

12. *Lindsaea* Dryander & Smith.

L. cultrata Sw. .. .. Cherrapunji.

13. *Sphenomeris* Maxon.

S. chusanum (L.) Copel. .. Shillong, Cherrapunji.

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14. *Schizoloma* Gandichand.

S. lobata Poir. .. .. Lakhimpur.

15. *Syngramma* J. Smith.

S. wallichi Hk. .. .. Khasi Hills (Jowai).

16. *Pteridium* Scopob.

P. aquilinum (L.) Kuhn. .. Abor Hills.

17. *Histiopteris* (Agardh) J. Smith.

H. incisa J. Smith .. .. Abor Hills.

18. *Pteris* L.

P. biaurita L. .. .. Aka and Abor Hills.
P. cretica L. .. .. Khasi Hills (Burnihat, Cherrapunji), Aka Hills.
P. ensiformis Burm. .. .. Gauhati, Khasi Hills (Shillong, Tharia).
P. Griffithii Hk. .. .. Abor Hills.
P. linearis Poir. .. .. Gauhati.
P. longifolia L. .. .. Gauhati, Khasi Hills (Shillong, Elephant Falls).
P. longipes Don. .. .. Aka Hills.
P. pellucida Presl. .. .. Gauhati, Abor Hills.
P. semipinnata L. .. .. Gauhati, Jorhat, Dibrugarh, Aka Hills.
P. quadriaurita Retz. .. .. Gauhati, Abor Hills, Khasi Hills (Shillong, Mawphlang, Mosmai, Cherrapunji, Jowai).

19. *Coniogramma* Fee.

C. fraxinea (Don) Diels .. Aka and Abor Hills.
C. javanica .. .. .. Khasi Hills (Shillong Peak, Barapani).

20. *Cheilanthes* Swartz.

C. belangeri (Bory) C. Chr. .. Shillong Peak, Khasi Hills (Shillong, Cherrapunji).
C. farinosa Kaulf. .. .. Gauhati, Khasi Hills (Shillong, Cherrapunji, Mosmai, Jowai), Gogwa Forest, Jorhat, Barpeta Road.

21. *Onychium* Kaulfuss.

O. japonicum (Thbg.) O. Kze. .. Aka Hills.
O. siliculosum (Desv.) C. Chr. .. Khasi Hills, Aka and Abor Hills.

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22. *Gymnopteris* Burnhardi.

G. involuta Hk. .. .. Shillong Peak.

23. *Pityrogramma* Link.

P. calomelonos (L.) Link. .. Gauhati, Shillong.

24. *Adiantum* L.

A. aethiopicum L. .. .. Gauhati, Tezpur.
A. caudatum L. .. .. Gauhati, Gogwa Forest, Jorhat.
A. capillus-veneris L. .. .. Shillong, Abor Hills.
A. lunulatum Burm. .. .. Gauhati, Vasishta Forest, Shillong, Gogwa Forest, Nowgong, Jorhat, Dibrugarh, Kulsi Forest, Tezpur.
A. peruvianum Klotz .. .. Gauhati (cultivated).

PARKERIACEAE

25. *Ceratopteris* Brongiart.

C. siliquosa (L.) Copl. .. .. Gauhati, Aka Hills.

DAVALLIACEAE

26. *Leucostegia* Presl.

L. immersa Presl. .. .. In and around Shillong, Manipur.

27. *Davallia* Smith.

D. bullata Wall. .. .. Aka Hills.
D. chaerophylloides (Poir) Stend. .. Aka Hills.
D. clarkei Baker. .. .. Mawphlang, Kohima.
D. griffthiana Hk. .. .. Aka and Abor Hills.
D. multidentata (Wall.) Hk. & Bk. .. Naga Hills.
D. pulchera Don. .. .. Khasi Hills (Shillong Peak, Cherrapunji), Aka Hills, Manipur.

28. *Humata* Cavanilles.

H. assamica (Bedd.) C. Chr. .. Assam—Copeland, 1947.

29. *Oleandra* Cavanilles.

O. neriiformis Cav. .. .. Khasi Hills (Shillong Peak, Elephant Falls, Cherrapunji).

30. *Nephrolepis* Schott.

N. cardifolia (L.) Presl. .. Khasi Hills, Aka and Abor Hills, Manipur.

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PLAGIOGYRIACEAE

31. *Plagiogyria* (Kunze) Mettenius.

P. glauca (Bl.) Mett. .. .. Aka Hills.

CYATHEACEAE

32. *Cyathea* Smith.

C. glabra (Bl.) Copel. .. .. Gauhati, Mawphlang.
C. khasyana (Moore) Copel. .. Mawphlang (?).

ASPIDIACEAE

33. *Diacalpe* Blume.

D. aspidioides Bl. .. .. Khasi Hills, Kohima.
D. wallichii Moore. .. .. Abor Hills.

34. *Peranema* Don.

P. cyatheoides Don. .. .. Cherrapunji.

35. *Polystichum* Roth.

P. aculeatum Roth. .. .. Aka and Abor Hills, Kohima.
P. aristatum Presl. .. .. Abor Hills.
P. auriculatum (L.) Pr. .. Shillong.
P. falcatum (L.) Diels. .. .. Aka Hills.
P. Hookerianum (Pr.) C. Chr. .. Aka Hills.

36. *Egenolfia* Schott.

E. appendiculata (Willd.) J. Smith .. Khasi Hills (?).

37. *Elaphoglossum* Schott.

E. conforme Schotte. .. .. Cherrapunji.
E. palustre (Hk.) J. Sm. .. Aka Hills.
E. petiolatum (Sw.) Urban. .. Aka Hills.

38. *Dryopteris* Adanson.

D. dentatus (Farsk.) Ching. .. Shillong.
D. flaccida (Bl.) O. Kze. .. Aka Hills.
D. felix-mas (L.) Schott. .. Kohima.
D. gracilescens (Bl.) O. Kze.
D. ochthodes C. Chr. .. .. Abor Hills.
D. scottii (Bedd.) Ching. .. Naga Hills.
D. stigera O. Kze. .. .. Abor Hills.
D. vastatum Blume. .. .. Aka and Abor Hills.

39. *Ctenitis* Christ.

C. fuscipes (Wall.) Ching. .. Abor Hills.

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40. *Tectaria* Cavanilles.

T. cicutanum Sw.	Kohima.
T. membranifolia Bedd.	Abor Hills.
T. polymorpha (Wall.) Copel.	Aka and Abor Hills.
T. variolosa (Wall.) C. Chr.	Gogwah Forest.
T. vasta (Blume) Copel.	Abor Hills.

41. *Lastrea* Bory.

L. ornata Fee.	Abor Hills.
L. prolifera Kuhn.	Abor Hills.

42. *Cyclosorus* Link.

C. extensus (Bl.) Ching.	Khasi Hills (Shillong, Mawphlang, Cherra).
C. moulmeinensis Copel.	Shillong, Barapani.
C. molliasculus (Wall.) Ching.	Aka and Abor Hills.
C. triphylla (Sw.) Ching.	Digboi.
C. parasiticus (L.) Farwell	Aka Hills.

43. *Athyrium* Roth.

A. bentamense (Blume) Copel.	Khasi and Abor Hills.
A. esculentum (Sw.) Copel.	Abor Hills, Garo Hills.
A. latifolium Moore.	Abor Hills.
A. lobbianum (Hk.) Moore.	Digboi.
A. macrocarpum (Bl.) Bedd.	Shillong Peak.
A. spectabilis Presl.	Lakhimpur, Kohima.

BLECHNACEAE

44. *Blechnum* L.

B. glauca (Bl.) Copel.	Kohima.
B. orientale L.	Gauhati, Jorhat, Dibrugarh, Abor Hills.
B. sps. (*B. orientale* var *grande* Kachroo)	Gauhati.

45. *Brainea* J. Smith.

B. insignis Hk.	Khasi Hills—C. Chr., 1938.

46. *Woodwardia* Smith.

W. radicans Sm.	Aka Hills.

47. *Stenochlaena* J. Smith.

S. palustris L.	Gauhati, along both sides of the Sibsagar-Dibrugarh Road.

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ASPLENIACEAE

48. *Asplenium* L.

A. achilleifolium (Lam.) C. Chr. ..	Aka and Abor Hills.
A. cheilosorum O. Kze.	Aka Hills.
A. ensiforme Wall.	Naga Hills.
A. finlaysonianum Wall. ..	Khasi and Abor Hills.
A. griffithianum Hk.	Abor Hills.
A. laciniatum Don.	Shillong, Aka and Abor Hills.
A. nidus L.	Gogwa Forest, Jowai, Lakhimpur, Abor Hills, Kulsi Forest.
A. nitidum Swartz.	Abor Hills.
A. planicaule Wall.	Khasi and Jaintia Hills.
A. unilaterale Lamk.	Abor Hills.

POLYPODIACEAE

49. *Dipteris* Reinwardt.

D. wallichii (R. Br.) Moore. ..	Abor Hills.

50. *Platycerium* Desvaux.

P. wallichii Hk.	Imphal.

51. *Polypodium* L.

P. amoenum Wall.	Mawphlang.
P. argutum Wall.	Shillong Peak.
P. dilatatum Wall.	Abor Hills.
P. europhyllum C. Chr.	Aka Hills.
P. excavatum Bory.	Khasi Hills (Shillong, Mawphlang, Cherra.).
P. lehmanni Mett.	Abor Hills.
P. lineare Thunb.	Jowai, Mawphlang, Abor and Aka Hills.
P. lachnops Wall.	Shillong.
P. membranaceum Don. ..	Jowai, Kohima and Abor Hills.
P. microrhizoma C. B. Cl. ..	Jowai.
P. nipponicum Mett.	Abor Hills.
P. normale Don.	Shillong, Jowai, Abor Hills.
P. oxylobum Wall.	Abor Hills.
P. pedunculatum (Hk. et Grew) Mett.	Aka Hills.
P. pteropus Bl.	Gogwah Forest, Dibrugarh, Abor Hills.
P. punctatum (L.) Sw.	Aka and Abor Hills.
P. superficiale Bl.	Manipur.

52. *Pleopeltis* Humboldt et Bonpland.

P. thunbergiana Kaulf.	Jowai.

53. *Neocheiropteris* Christ.

N. phyllomanes (Christ.) Ching. ..	Abor Hills.

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54. *Pyrrosia* Mirabel.

P. adnascens Sw. ..	.. Gauhati, Shillong (Barapani), Gogwah Forest, throughout the plains of Assam, Abor Hills,
P. Boothii (Hk.) C. Chr.	.. Aka Hills.
P. flocculosus (Don.) C. Chr.	.. Cherrapunji, Jorhat, Sibsagar, Dibrugarh, Abor Hills.
P. heteractis (Mett.) Ching.	.. Cherrapunji, Aka Hills.
P. lanceolatus (L.) Alston.	.. Gauhati-Pandu Road.
P. lingua Desc. ..	.. Abor Hills.
P. numularifolia (Sw.) Ching.	.. Aka and Abor Hills.
P. porosus Pr. ..	.. Aka Hills.
P. penangianus (Hk.) Ching.	.. Shillong Peak.

55. *Pteropsis* Desvaux.

P. carnosum J. Smith. ..	.. Abor Hills.
P. piloselloides Des. ..	.. Gauhati, Jorhat, Sibsagar-Dibrugarh Road, Khasi Hills.

56. *Microsorium* Link.

M. lucidulum (Roxb.) Copel.	.. Abor Hills.
M. scolopendria (Burm.) Copel	.. Aka Hills.

57. *Leptochilus* Kaulfuss.

L. axillaris Kaulf. ..	.. Abor Hills.
L. decurrens Bl. ..	.. Dawki Road.
L. heteroclitus C. Chr. ..	.. Abor Hills.
L. lanceolata (Hk.) Fee.	.. Dawki Road.
L. scalpturatus (Fee) C. Chr.	.. Jowai Road.

58. *Colysis* Presl.

C. hemionitidea (Wall.) Presl.	.. Aka and Abor Hills.

59. *Dendroglossa* Presl.

D. minutula (Fee) Copel.	.. Assam—Copeland, 1947.

60. *Pseudodrynaria* C. Chr.

P. coronans Ching. ..	.. Nongpoh, Abor Hills, Manipur.

61. *Drynaria* Bory.

D. pleuridioides Presl. ..	.. Naga Hills, Cherrapunji, Shillong.
D. quercifolia (L.) J. Smith	.. Gauhati, Gogwa Forest, Kulsi, Jorhat.

62. *Crypsinus* Presl.

C. hastatus Copel. ..	.. Shillong, Jowai.
C. griffithianus Copel. ..	.. Aka Hills.

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63. *Arthromeris* (Moore) J. Smith.

A. wallichiana Ching. .. .. Mawphlang.

64. *Loxogramme* Presl.

L. parallela Copel. .. .. Aka Hills.

VITTARIACEAE

65. *Antrophyum* Kaulfuss.

A. coriaceum (Don.) Wall. .. Aka and Abor Hills.

66. *Vittaria* Smith.

V. elongata Sw. .. .. Cherrapunji, Abor Hills, Manipur.
V. flexuosa Fee. .. .. Naga Hills.

MARSILEACEAE

67. *Marsilea* L.

M. quadrifolia L. .. .. Gauhati, Jorhat, Dibrugarh, Goalpara, Aka Hills.

SALVINIACEAE

68. *Salvinia* (Mitcheli) Adanson.

S. natans L. .. .. Gauhati, Aka Hills.

69. *Azolla* Lamarck.

A. pinnata R. Br. .. .. Gauhati.

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FISH TRAPPING IN INDIA

By T. J. Job and V. R. Pantulu

Introduction

Trickery seems to have been one of the earliest manifestations of the dawn of intelligence in primitive man. From direct, face to face attack of prey which was laborious as well as risky, the caveman began to develop methods of sly approach and sudden grabbing, which by slow and imperceptible degrees, evolved into still more productive methods of capture by trickery and trapping. The cleverer of our ancestors thus conceived of many a simple but effective snare to way-lay their victims such as the birds of the air, the beasts of the woods, and the fishes in the waters. Trapping was probably the earliest device that man ever resorted to for catching fish long before nets and other highly evolved tackle could ever be thought of. Some of the primitive types of traps, probably invented by the most ancient men, can still be seen in use in many parts of the world. This is not surprising when it is remembered that most of the traps being fixed engines do not require continuity of attention and vigilance on the part of the operator but can be left to themselves to function and secure a catch while the owner is away reposing or engaged in other occupations. Diverse fish traps ranging from the simplest to the most complicated and amazingly effective types, are in vogue in the different waters of India. A number of these traps have been described or referred to by various authors among whom special mention should be made of Wilson (1917), Day (1873), Hornell (1924) and Thomas (1870). What is attempted in the present paper is an analytical treatment of the different types of fish traps, exclusive of nets and missiles, tracing the complex from the simple along lines of progressive specialization in relation to their pattern and to the fisheries for which they are suited, as also an estimate of the destructive effects of some of them. It is not always possible to draw clear lines of demarcation between the various types of traps which sometimes overlap in respect of structure or pattern, and hence only a rough classification into convenient groups can be made. While the use of the more effective and desirable types of traps may be extended and popularized in suitable waters where they are at present unknown, that of the defective and harmful has to be checked. Lest, however, restriction be unnecessarily oppressive to the poor fishermen, only genuine cases of unhealthy practices as ascertained by the extent of estimated damage in actual working, are to be prohibited.

Methods of Trapping

1. Groping.—The simplest and yet the most dexterously used trap ever directed against fish is the human hand itself. Fish lurking in crevices and amidst rocks and those that live in shallow waters and burrow into the mud are searched for and caught by hand. Gudger (1951), in his interesting note on 'Fishing with hand in Asia' has elaborated some methods of groping in vogue in different parts of the continent. In a communication to Gudger Dr. S. L. Hora has cited an observation by Mr. Khajuria of an interesting method of fishing in the Kashmir State

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where large parties of people squat close together across a shallow stream, thus forming a barricade, and move up the river slowly. Fishes living among rocks and in pools get disturbed and in their effort to make an escape, strike against the human barricade and get into the folded parts of the legs. They are then skilfully caught with the hand and thrown on the bank. On many a rainy night the senior author of this paper has with the help of a torch-light seized air-breathing fishes like murrels and climbing perches from under wet railway lines as the fishes wander over land from one pond to another. Often he has watched Sri Natesan, an expert tank diver in Madras chasing pearlspots until they are trapped in their very lair and deftly grabbed. He has also joined in catching Orange Chromides (*Etroplus maculatus*) in clear shallow waters in Malabar by driving them with scare rods to settle in the silt when they are easily gathered. The fisherman holds a long bright banana mid-rib or split bamboo in each hand and on spotting a group of Chromides, plunges the rods inclined towards each other, downwards and forwards, thus enclosing the fish between them. Scared by the rods thus appearing on either side and towards the front, the fish literally hide their heads in the silt, as the ostrich would do in the sands and easily lend themselves to be culled.

The Bhil tribes in the Nasik district of Bombay are observed to fish effectively in small streams and rivulets by groping, aided by a scare line device. A long rope to which stalks of *jowaree* (millets) are tied at intervals of 3 to 4 feet is stretched, slightly submerged, across the river. The men holding the ends of the rope on either bank move slowly upstream. Five to ten fishermen follow at some distance behind the rope at intervals along the whole length, beating and splashing the water. The scared fish seek shelter near the banks, where a party of Bhils are in readiness to grope for and collect them.

Catching fish by hand is in vogue throughout the country. Usually fish caught by groping are Murrels, Spiny Eels, the Climbing Perch, *Clarias*, *Saccobranchus*, *Etroplus*, *Glossogobius*, etc. Crabs and prawns are also collected in fair numbers (Hora, 1932). A knowledge of the habits of the fish and some skill and practice can render this method fairly remunerative.

2. STRANDING.—An equally primitive method of fish capture, is what may be termed 'stranding' which is fairly common in shallow areas. Hornell has mentioned a number of instances.

(i) *Bunding* (*Osa*—Assam ; *Chera Kettu*—Malabar)—Selected areas of water are separated from their connections with the main body by erecting low earthen bunds. The water from the areas thus enclosed is bailed out, and whatever fish are left stranded are gathered. In some cases, to save the trouble of bailing out water, the bunded areas are left alone till they partially dry up, and then the fish are collected. This is frequently practised in shallow swamps and burrow pits; but only small fish are often caught and hence the method is not very paying.

(ii) *Screening*—This method is in vogue in tidal regions.

(*a*) *Screen Wall* (*Adichil*, *Thaithal*—Malabar; *Thatta*—Orissa, Fig. G, Plate I): A convenient area is surrounded at high tide by erecting bamboo screens, and when during low tide the water recedes, the fish present are stranded at the bottom or are found floundering in shallow pits from where they are easily collected. The screens are in pieces, each about 25 to 30 feet long and 3 to 5 feet wide, and made of slender bamboo splinters are held together by twining with coir or jute strings along the upper and lower margins as well as at regular intervals between these. Shallow tidal creeks are also similiarly cut off during high tide by fixing

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bamboo screens across their mouths, and when the water ebbs out at low tide, the fish left behind are collected. In *jheels* (long canal-like waters) shallow areas are enclosed off from the main body with screens. The areas thus enclosed are then sub-divided into small compartments by erecting low earthen bunds. These are then emptied of water by bailing, and whatever fish present are caught.

(*b*) *Screen Wall and Chamber*: Another interesting and slightly complicated way of utilizing bamboo screens is to fix them as barriers across small streams or back water channels. At intervals in the vertical screens are set, circular, heart shaped or rectangular trap chambers, also of bamboo screens and having a narrow entrance. A trap chamber is made by arranging a length of screen in such a way that the middle part of its length forms a circle, ovoid or a rectangle, and the ends are brought close together to form a narrow passage through which it is difficult for the fish to escape once they enter the chamber. Generally mullets, pearlspot, prawns, etc. are caught by this method.

(*c*) *Closing Screen*: Another method of using bamboo screens for catching fish of fairly big size is in use in some parts of Orissa. A long bamboo screen is placed in a tank in a V form with the apex of the V near the bank. Fishermen standing in a line with each arm of the V start disturbing the water by beating and simultaneously converge thus driving the fish into the open arms of the screen. As the men close in upon the opening, the two arms of the V screen are also brought together. The sides of the V are then pressed towards each other till they almost touch. From the narrow enclosure thus formed the fish entrapped are caught by the hand or a small hand net. Pond fishes like carps, catfishes, murrels, feather-backs, etc. are caught by this method.

(iii) *Platform Trap or Sieve Trap* (*Chip*—Punjab; *Mudgi*—Hyderabad)—Here fish are got stranded in big rectangular platforms (about $5' \times 4'$) made of split bamboos interwoven so as to leave one inch square interstices. These platforms are erected under small natural waterfalls or artificial 'falls' like flows of water created by erecting a bund of mud and stone with a gap of a few feet in the middle across streams or creeks, or under holes made in dams, through which water escapes. The ways in which the platforms are fixed differ in detail in different regions. In the Indus system of rivers the *Chip* is erected in such a way that it slopes upwards on the downstream side. The fish coming down the stream fall on the platform through which water and small fingerlings escape, leaving the bigger fish stranded, which are promptly collected by the fishermen. The *Chips* are usually fixed at the close of the monsoon.

The *mudgi* used in the Manjra river in Hyderabad State is similar and is described by Wilson (1917). At various points in the river small bunds are erected by placing stones and boulders across the river along with plants and weeds. At convenient places gaps are left in the dams through which the water passes. Under such gaps, platforms as described above, are fixed and on this the fish get stranded.

(iv) *Waterfall Basket*—A large, deep, strongly made basket is kept at the base of a small waterfall to catch the falling fish which are prevented from escaping by the impact of the fall and by more fish falling on them.

(v) *Platform-cum-Baskets*—A combination of the platform and baskets is used in Baroda to catch grey mullets as noted by Pillay (1949). Here also the platform which is termed *patta* is erected under a gap in the mud dams erected across small creeks. A big basket is placed on each side of the *patta*. If the fish trapped on the platform try to leap away, they fall into the baskets from which escape is nearly impossible.

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The *Yevu* used in the rivers of South Canara and referred to by Thomas (1870), is another platform trap with which a simple cage trap (vide *infra*) called *Baikuri* is often used, while the *Jepu* is a simpler form of the same device used in smaller falls.

(vi) *Leap Traps*—

Leap Pocket: The leaping habit of certain fishes is taken advantage of in the application of a number of devices specially suited for their capture. Fish caught in leap traps are generally in prime condition and fetch a good price. In parts of Orissa and in the Bhavani and other rivers in Madras, pocket-like nets and baskets are fixed on the sides of small waterfalls either natural or artificial as in anicuts. Carps like *Barbus*, *Cirrhina*, etc., migrating upstream, leap against the fall and those which fail in the attempt fall into the pocket-nets or baskets, from where they are gathered periodically. Clumps of shrubbery are sometimes kept in these traps to prevent the stranded fish from leaping out.

Leap Boat: In small creeks, drainage channels and streams, fish going upstream during the rainy season and returning downstream at the close of the season are caught in a simple way. A bund is thrown up across the stream leaving a narrow passage near the middle. This gap is barred by a strong bamboo screen which permits the flow of water but acts as an obstruction for the fish to cross. A boat or raft is anchored on one side of the screen. The position of the raft (upstream or downstream) varies with the seasonal migrations of the fish to be caught. Fish finding the passage barred try to leap the barrier and in so doing fall into the boat and are caught. In some cases during the night a torch or lamp is kept burning in the boat to act as an additional attraction for the fish to jump. When the volume of water is large and the current strong, the earthen bund is replaced by long stretches of bamboo screens, to the downstream side of which a long curtain-like net is attached above the water level on strong bamboo poles to form a pocket. The fish which try to jump off the screen fall into the pocket from where escape is impossible.

Platform-cum-Bush (*Chaatam*—Malabar, Plate I, Fig. F): This is a method of fish trapping in vogue in the extensive paddy fields of Malabar where a set of fields is usually connected with a common channel. When after the floods the inundated fields drain into the channel, a good crop of fishes consisting of fair sized murrels, carps, mullets, prawns, etc., appears in the fields. Screens are raised on the submerged main bund which is broken by the channel. Fish from all over the field system move seeking deeper water. The screen wall on the main bund helps to lead the fish in the direction of the channel where a low screen wall surmounted with a two-storied screen-box is set up with the help of bamboo poles. The first floor of the screen-box is open to the side facing the set of fields and on the top is a platform with raised sides. Confronting the obstruction offered by the lower chamber of the screen-box, the fish leap and land on the platform, where they are trapped among twigs and bushes purposely placed there. The platform is about a foot to a foot and a half above the water level. The catches are collected periodically.

Leap Raft (*Chali*—Bengal, *Chanchi*): This is a more specialized contrivance involving the same principle, and used in rivers and streams in the Indo-Gangetic region, for the capture of the freshwater mullet, *Mugil corsula*. The whole contrivance consists of a rectangular float of reed matting 20 to 30 feet in length and 3 to 4 feet in width. Along each of the longer margins of the matting a rim of greenish white midribs of plantain leaves is attached, which serves the purpose of keeping the raft

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afloat and also acts as a scare inducing the mullets to leap from the water. Ropes are attached to the two corners of one of the longer sides, by means of which the whole float is towed by a fisherman. Another fisherman follows in the wake of the raft. When a shoal of mullets is noticed the raft is towed towards the bank, at the same time the shoal is driven towards it by beating the water and making noises. When the mullets approach the raft they are frightened by the gleaming white surface of the plantain midrib and in their attempt to escape by leaping over it, they land on the reed matting from where they are promptly collected by the fisherman standing behind it.

A slight variation of the above device is used in the Murshidabad district of Bengal in conjunction with a boat. The raft in this case is much broader than the one described above and it is manipulated from a boat with the help of ropes tied to it. The raft which is generally 28′ × 8′ is made of *nal* reed, with supporting bamboos tied along its length to strengthen it. Along the margin of one of the longer sides and upon it a narrow net about 4 inches in height is set up supported by sharp upright bamboo pieces. To each of the corners of the opposite long side is tied a long rope buoyed up by *shola* floats at intervals. To the end of each of these ropes with floats is tied another long rope without floats which is held by a fisherman on board the boat. The raft is set afloat in the river parallel to the boat but at a considerable distance from it, and the floatless ropes which are ultimately fastened to the raft through the floated ropes, are held securely by the fishermen on the boat. When a shoal of mullets appears swimming within the space enclosed by the long ropes connecting the raft and the boat, the two ropes are carefully passed over to the opposite ends of the boat, manipulating them in such a way that the floats attached to the ropes on either side are brought close together. The converging of the floats coupled with the noise made by the fishermen aboard frighten the shoal which consequently swims towards the raft and confronted with the latter, the fish leap out of the water and fall on the raft. Once on the raft, escape becomes very difficult for them because of the marginal net. Considerable skill and practice is however required in the manipulation of the ropes and the raft, without which the shoal may not swim at all towards the raft.

A slight variation of the same method described above is in use in Muzaffarpur district. The raft in this case is made of jute stems with the margin raised on all sides for a couple of feet. The entire raft forms a shallow rectangular tray about 20′ long and 7′ wide. Bundles of reeds are bound along the longitudinal margins to strengthen the raft. To each of the ends of one of the long sides a rope with *shola* floats is tied. The raft is operated from a boat in the same manner as described above.

Another modification of the *Leap Raft*, also in use in Muzaffarpur district, is what is called *Chota Sirki*. The raft here, made of jute stems is very much narrower than in the previous case, being only about 18 inches wide and about 20 feet long. It is attached in a sloping manner along one side of the canoe which stands only slightly above the water level. The raft is supported by split bamboo pieces which project a short distance beyond the margin of the raft towards the canoe, where in attachment to a long bamboo pole fixed along the length of the canoe they form a sort of rough hinge-like arrangement. This device is usually operated on moonlit nights. In operation the raft is lowered down into the water obliquely till its outer margin is submerged under water by a few inches. Mullets swimming about approach the raft probably attracted by the white jute

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stems but once they come in contact with the raft they get scared and try to leap over it only to fall into the canoe.

Changaadam or Changala-paichil: An identical but more efficacious method of raft trapping known as 'Changaadam' or 'Changala-paichil' is in vogue in the backwaters of the Malabar coast. Two shallow dugout canoes are connected to each other by long bamboo poles one tied at the anterior end and another slightly shorter one tied at the posterior end. On the outer side of each canoe, a net is fixed supported on sticks inclined upward at an angle of about 25°. Sand and stones are placed in the dug-outs to make them heavier so as to have a low free board. The boats are then filled in with twigs and shrubbery.

A long scare-line is made of pieces of chain connected by lengths of rope. Each end of the scare-line lies in a canoe, and the entire length lies in semi-circle under the water behind the two canoes. The dugouts are moved forward either with the help of long poles or paddles dragging the chain slowly. The sound produced by the links scares the mullets and prawns in the area, which leap wildly into the air and ultimately fall into the dugouts and get caught in between the bushes laid in them or in the nets stretched out.

3. Bush Traps.—

(i) *Bush Laying* (*Pathaazham*—Malabar)—Another method of trapping, allied to stranding, fish is to take advantage of the attraction which fish sometimes feel for shade and to place leafy branches of trees, bushes, coconut inflorescence stalks, etc., in backwater channels or small streams, with stakes fixed around them to avoid their being displaced by the current. The effect is that of 'a huge Christmas-tree', as Hickling (1951) puts it. These bushes are allowed to remain there for about a fortnight, during which period fish attracted by the shelter and food afforded by the decaying leaves and slimy overgrowths, collect there. The fishermen then enclose the area covered by the bushes with a bamboo matting screen, remove the bushes and collect the fish with the help of a dip net.

(ii) *Bush Pits*—In the *beel* areas of Bengal during the rainy season, bushes and leafy branches of trees are thrown in small pits called *Khatis* in inundated areas. As the water level goes down after the rains, fish seek shelter in these pits, attracted by the protection and food. Later the branches are removed and the sheltering fish are collected by hand or with the help of a cover basket. Fairly good catches are usually obtained.

(iii) *Bush holds*—(*a*) *Boat Bush hold*: In many parts of the country, boats not in use are usually kept submerged in water to prevent the wood from getting damaged. The interior of these boats is sometimes filled with leafy branches of trees, twigs or straw to attract fish. After the expiry of about a month, a net is thrown over the boat and the latter thus covered is dragged ashore. The sheltering fish are then removed. The fishes caught thus are murrels, spiny eels, *clarias*, etc.

(*b*) *Eel Cage* (*Aaralkoodu*—Malabar, Plate I, Fig. H): Eels and spiny eels which are in the habit of sheltering in clumps of weedage are often caught in large numbers by laying clumps of straw, coconut inflorescence stalks, etc., in coconut leaf 'baskets' open at both ends and kept submerged in canals. The basket is cyclindrical, about 40″ in length and 15″ in diameter—the dimensions and even the shape may vary—and sometimes the cage is weighted by heavy stones.

(*c*) *Mattress Bush-hold* (Plate V, Figs. F and G): In the Brahmaputra river and its tributaries in Assam, bush-laying is practised as follows:—

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A frame (about 6′×6′) of strong bamboo splinters, woven closely is prepared and over that are laid twigs and leafy branches of trees to form a coarse mattress. It is then covered on the top with water hyacinth plants and kept submerged fixed in the bed of the river with bamboo poles. Heavy stones are also attached to the frame to serve as weights. From time to time the fishermen go by boats to the spots where these devices are fixed, carefully cover the entire device with a net and lift it out of water, and collect the fish. River Brahmaputra abounds in dolphins. Smaller fish when chased by these dolphins often seek protection in this shelter and thus add to the 'catches'.

(d) *Triangular Bush Trap* (*Chogra, Shagra, Sharga, Okhra, Sagra*—Bengal): This is allied in plan to the 'Eel Cage' but is closed at one end and has a triangular mouth at the other. It is comparatively, large nearly 5 feet long and about 3 feet wide at the mouth. It is fairly strong, being constructed of bamboo. The triangular mouth leads into a long chamber with flattened sides converging towards the closed end where sometimes a door is provided to facilitate removal of the catch. The trap is strengthened by a few crossbars of bamboo fixed at intervals across the cavity of the chamber. Attached to each end of the base of the triangular mouth are two long ropes. In operation it is loosely filled with leafy branches and is left anchored with the help of the ropes to stakes driven in the bed of the stream, with the mouth facing the flow. In four to five days, fish and prawns would have made the shelter provided by the trap their rendezvous. Then eight or nine fishermen cautiously drag the trap ashore and gather the catch, which is often considerable, either through the mouth or through the door at the closed end.

(e) *Bush Lures for Flying Fish*: The flying fish fishery which is very lucrative in the deep sea waters of the Coromandel coast is tackled primarily by the application of bush-laying as detailed by Hornell (1950). Fishermen go out in highly specialized 'deep sea' catamarans with large branches of shrubbery usually consisting of *Tephrosia purpurea* (*Kavalai*—Tamil) or the neem, *Melia azadiracta*. The bundles of shrubs are cast overboard tied to the ends of long ropes generally measuring 10 to 30 fathoms. Each bundle is so buoyed with a float of light wood that it will remain just submerged. The catamaran with the fishermen standing up offers some resistance to the wind and so drifts more quickly than the bunches of shrubs which stream away from the catamaran on the windward side. Flying fish have the habit of depositing their spawn on seaweeds and are therefore easily attracted by these artificial weeds appearing in the water. Hence they soon begin to gather around these lures, which are then drawn towards the catamaran, and the fish are smartly scooped up by a special dip net.

4. Basket Traps.—Enclosures of basket work of different materials are used as effective traps in shallow as well as deep waters. They vary considerably in shape, in size and in the mode of operation. While some like the cover baskets and scoop traps are movable, others such as the cage traps and box traps are usually fixed.

(i) *Cover Baskets* (*Poluha*—Orissa; *Polo*—Bengal; *Uduka*—Mysore; *Gutta guli*—Canara; *Ottal*—Malabar; *Muchu*—Bihar; *Utad, Thapa, Chhapa*—Madhya Pradesh, Plate I, Figs. A, B, C, D, E)—One of the simplest of basket traps in vogue is what is called variously as the cover basket, the plunge basket, or wicker hand trap. This device is used almost throughout the country though varying in shape and size depending on the material that goes into its construction and on the local preferences

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and traditions. It is used either by itself or in conjunction with a scare line or a torch.

(*a*) A typical *cover basket* is a roughly conical contrivance open at both ends and usually made of bamboo splints or cane. It is about 2 feet high with a wide lower mouth about 1½ feet in diameter and a narrow opening about 6″ in diameter at the top. The splints are tied together with strong coir or jute. A number of encircling lacings of the same material are given at intervals to strengthen the whole contrivance. The free ends of the splints at the wide mouth are usually sharpened, so that the device could be pushed down and fixed temporarily in mud. The sides of the narrow top opening are bound with coconut leaflets, jute or coir rope to form a sort of thick ring, or sometimes even reinforced with a wooden ring to prevent the hand from being hurt.

The cover basket is mostly used in summer months in shallow waters especially with a muddy bottom, such as swamps, tanks, *bells, jheels* and streams. The basket is plunged into the water wherever the presence of fish is suspected and its lower mouth pressed into the bottom, thus virtually imprisoning the fish in the trap. The fish inside are then searched for and caught by the hand which is introduced through the narrower top opening (Plate I, Fig. D). Generally fish like *Ophicephalus, Clarius, Saccobranchus, Anabas, Eels*, etc., are caught in this trap. While cover baskets can be operated singly, in some cases an entire village or a whole tribe or community of fishermen set out for a joint operation. They stand in a line in the form of an arc in a vast stretch of shallow water while others disturb the surrounding water and drive the fish towards the men with the cover baskets. Thus vast sheets of shallow water are systematically divested of fish. When fish with poisonous spines are caught, the main spines are deftly broken off. The cover basket fisherman often in his hurry, bites and keeps the first catch held between his teeth while searching for more in the trap. Spiny species like *Anabas* sometimes manage to wriggle out of the hold between the teeth and slip in choking the captor to death, the dorsal spines of the fish sticking in his throat, and hence the popular name 'Chowane-kolli' for *Anabas* in Malayalam, meaning Killer of Chowan (Chowan is a sub-caste in Malabar).

(*b*) *Cover Basket-cum-Scare Line* (*Belupu*—S. Canara): In certain parts of the South Kanara district the cover basket is often used in conjunction with a scare line. It is more effective in small rivers, creeks and swamps where the force of the current and the depth are not great and shallow areas abound. It is operated in all seasons except during rains.

The scare line locally known as 'Belupu' consists of a coir rope ¾″ in thickness and 100 to 150 yards in length, depending on the width of the river. Along the whole length of the rope are tied strips of tender white palmyrah leaves at intervals of 4″ to 6″. At a distance of every three yards, stones weighing a pound or two are tied to the rope to serve as weights. One end of the 'Belupu' is provided with a loop and to the other end is tied a short piece of bamboo. During the operation the loop is slipped on to the leg of a fisherman who takes up his position on one bank. The other end with the bamboo rod is held by another fisherman who gets on the opposite bank, the scare line being allowed to stretch submerged in the water. The line is thus dragged against the current, the bamboo rod end being taken much in advance of the other end. The scare line thus begins to move under water in the form of an arc. Five to ten fishermen ready with cover baskets follow in the wake of the line in the shallow area near the bank at the rear end. Fish in their curiosity are at first attracted by the gleaming white, slowly moving leaflets. But on

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closer approach, being confronted with the line, they get presumably frightened, and hence instead of crossing it, swim along the line till they reach the shallow areas near the bank at the rear end. Thus a number of fish swimming in the river get collected at this part of the arc from where further progress along the line is impossible because of the bank. Consequently they make a desperate bid to overcome the scaring obstruction by swimming below the line downstream through the spaces in between the hanging leaves. There they are promptly captured by the men with the cover baskets. This method of catching fish is fairly remunerative and 5 to 6 fishermen working for few hours are said to capture one to one and a half maunds of fish. Many varieties of riverine and estuarine fish like carps, mullets, etc. and crabs and large prawns are caught by this method.

(ii) *Scoop Traps*—These traps derive their name from their mode of operation during which they are lifted out of water with a scooping motion to collect the fish entrapped in them. Numerous varieties of these traps are in use in various parts of the country. In general these devices are not very effective, the number of fish caught by them being very few. The catching power of these traps being thus limited, their destructive effect on fisheries is not appreciable except when used against brood fish or fish seed.

(*a*) *Bell Scoop* (*Tura*—Bengal): The bell scoop is used widely in Bengal. This is a simple trap resembling the cover basket in general shape and dimensions and is also a conical or sub-conical contrivance made of bamboo or cane strips. The mouth at the lower end has a diameter of about two feet; but the narrower end unlike the cover basket is closed and is formed into a thick handle. The fishery to which this trap is suited and types of water in which it is used are the same as those for the cover basket, though only fish of smaller size are caught. This device is plunged into the water where fish are likely to occur with the open end directed downwards. Then with the help of the handle the trap is suddenly lifted out of water with a scooping motion, mouth upwards, thus lifting the fish stranded in the basket.

(*b*) *Monk's Hood Scoop* (*Hocha*—Bengal, Plate II, Fig. A): This is used widely in Bengal, Bihar, Assam and Kumaon. The trap is made by folding into two and joining together one of the four sides of a rectangular open-meshed bamboo mat, the margins of which are reinforced by split bamboo splints. The mat thus folded bears a close resemblance to a monk's hood. Across the wide triangular mouth of the trap a bamboo pole is attached passing from the centre of the base upwards to the apex and projecting beyond it to form a handle. The dimensions of the trap vary considerably. The length from the centre of the base to the apex of the triangular mouth is about 21″, the breadth across the mouth is about 14″, and the maximum depth of the trap is about a foot. In operation the lower margin of the trap is pressed down into the mud. The water area immediately in front of the mouth of the trap is then disturbed violently. Fish in the area get scared and are driven into the trap, which is lifted from time to time to remove the catch. The device like the preceding scoop trap is used in the shallow waters of streams, rivulets, pools, tanks, etc. Usually fry and fingerlings are caught in this trap.

(*c*) *Lever-line Scoop* (*Nui*, *Gang*—Bengal): This trap is used widely in hilly tracts. It consists of a cylindrical trap about 20″ long and is made of split bamboo or cane pieces. It is open at one end and closed at the other; the diameter of the open end is usually about 8″ to 10″. The shape of these traps differs in different localities, some of these being straight and others slightly curved. The closed apex is usually eccentric

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in position. A strong bamboo rod about 3 feet long is attached along one side of the cylinder in such a way as to project well beyond the hinder closed end, thus forming a handle. A loop of string (the line) is attached to the same bamboo rod close to the mouth. The trap is placed under water in a shallow stream or tank and the open end is pressed slantingly against the mud at the bottom. The projecting bamboo handle is held with one hand and the rope or string attached to its distal end with the other. Thus set the trap is pushed along till the fishermen suspects that some fish have entered into it and then by suddenly pulling the rope, the trap is lifted out of water. Thus whatever fish happen to be in the trap are caught. This trap is usually operated in shallow waters especially in pools in the hill streams and usually small species are obtained.

(*d*) *Semi-fixed Scoop* (*Doar*—Bengal, Plate II, Fig. B): This is a sub-cylindrical device made of slender bamboo splints, used widely in Bengal, Bihar and Orissa. The trap is about 18″ long open at one end and closed at the other, The diameter of the open end is 10″. At the closed end all the bamboo splints are tied together with a slender strip of cane to form a sort of handle about 4″ long. The position of the handle is eccentric. This contrivance is operated in paddy fields particularly at the inlet and outlet openings in bunds. The handle of the trap is held with the hand and it is set against the flow of the water in close apposition to the opening in the bund. The area in front of the trap is then disturbed by splashing and beating the water. Consequently the fish rush into the trap. Then the trap is lifted along with the fish. The catch usually consists of small fish, though occasionally fairly big sized Murrels, Eels, Climbing Perches, etc., are also caught. The semi-fixed scoop represents a transitional stage from a movable engine, like the typical scoop trap, to a fixed engine such as the cage trap.

(*e*) *Net Scoop*: A modified form of cover basket with a net, which may be termed the net scoop is in vogue in various parts of Bengal. This contrivance is used in shallow waters with a muddy substratum, particularly in the summer months. In general shape this trap resembles closely a cover basket. The frame of the trap consists of four split bamboo pieces tied together at one end, and joined at the other at equidistant points to a bamboo ring having a diameter of 2 to 2½ feet. The frame is covered over by a net. At the wide mouth at the lower end the net is laced around the circumference of the bamboo ring and at the top the net extends beyond the length of the bamboo frame by about ¾ of a foot forming a cul-de-sac. A loop of string passes over the apex, so that when the trap is not in operation the passage between the bag and the main chamber is closed. In operation the contrivance is plunged into the water wherever fish are suspected, in such a way that the entire trap lies submerged. After the trap is pressed down into the substratum, the loop at the top is loosened thereby creating a communication from the main chamber into the cul-de-sac. Fish imprisoned in the trap in their desperate attempt to escape rush into the bag. The whole trap is then lifted out of water with the mouth end upwards with the fish collected in the bag. This device is as a rule not very effective, but it has one advantage over the cover basket in that the fisherman escapes getting hurt especially when fish possessing poisonous spines are caught.

(iii) *Cage Traps*—In effectiveness as well as in the deleterious effects on the fisheries, the cage traps rank among the most important groups of fish traps in India. Being extensive in use, they attain a diversity of shapes and sizes, though generally they are cylindrical or sub-cylindrical contrivances made of fine bamboo splinters, cane, grass or midribs of

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palm leaflets, depending on the availability and abundance of the material in the locality concerned. The interstices in these traps are narrow, usually ranging from $\frac{1}{25}''$ to $\frac{1}{4}''$ so that it is impossible even for small fry to escape through them. As a general rule cage traps are open at one end and closed at the other. From the wide, open mouth the bamboo splinters converge gradually to form ultimately the closed hind end. In some cases the hind ends of the splinters are tied around a short piece of bamboo to serve as a handle. If desired, this handle can be loosened to remove the fish entrapped without disturbing the position of the trap. In instances where the hind end of the trap is truncate, a door-like structure is provided or even the entire rear wall may be detachable to facilitate the removal of the catch. These devices are set in various types of fluviatile waters like hill streams, rivulets, tidal creeks and irrigation channels and in paddy fields. While generally the cage traps or sometimes also the box traps described later in this paper are placed with the face directed against the flow to catch the fish moving with the current, they are frequently fixed in the reverse direction to catch fish which migrate against the current. Fishermen, well aware of the habits of the different species adapt these traps to the runs and the fishes to be caught. Bunds and obstructions are often constructed across the streams to direct the flow of the entire water through small openings against which traps are set, thereby practically straining whole streams of their fish populations. These traps are usually operated during the rains mainly from June to October and fry as well as brood fish migrating for spawning purposes are caught in them. Thus the number of fry destroyed every year by the innumerable cage traps in operation is beyond estimation, and the problem has attained such a magnitude that remedial measures are urgently called for to stop this appalling waste.

Cage traps can be broadly divided into two groups, viz. (*a*) simple, and (*b*) valved.

(*a*) *Simple Cage or Cone Cage* (Plate III, Fig. A) : *Toradang* of Santhal Parganas, *Cuma* of Nagpur, *Kannillatha kuruthi* (eyeless trap) of Malabar, *Khiainchi* of Assam and *Putchira* of Chota Nagpur.

This is the simplest of the cage traps and is roughly cylindrical in shape. The dimensions vary in different localities and range from 1 to 12 feet in length depending on the environs in which they are used. The most common is about 2 feet long open at one end and closed at the other, the diameter of the open end being about 9″ and that of the closed end 4″, At the closed end there is a detachable hood. The cage is constructed of fine, closely set, bamboo splinters laced together with cords made of jute or other fibre. To strengthen the trap, three hoops of split bamboo or cane encircle the trap one at the mouth end and others at intervals of about 8″. The number of cane hoops and lacings of jute cord increase with the increase in length of the trap.

These traps are set where the current is rapid as in openings made in bunds constructed for irrigational purposes, or at inlet and outlet passages in inundated paddy fields. Across streams, rivulets and hill streams, hurdles are raised by driving strong bamboo stakes in the bed. Split bamboo is interlaced to these stakes and the whole hurdle is reinforced with bushes. At intervals in such hurdles small passages are left through which the water escapes with extra force. In close apposition to these openings are set long cage traps so that the entire body of water has to pass through these traps. The interstices in these traps are quite small and as the water passes through the traps, fish, both fry and grown up, are hurled into them by the force of the current. Although thus the stream

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is not stopped, no fish, big or small, can pass down. Thomas (*op. cit.*) refers to such 'voddu' hurdles used in Coorg and South Canara. Once inside the traps (fixed in gaps in the hurdles) the fish cannot escape by swimming backwards, because of the rush of water and the limited space. Further they are also choked by more fish being hurled on to them. The hurdles are either in a straight line or in V form; in the latter case an opening is made at the apex of the V against which the trap is set (Plate IV, Fig. C). In some localities the hurdles are made of screens of reeds strengthened with stones and mud. In shallow streams boulders are placed across the current in the form of a V, and gaps in between the boulders are closed with mud. As in split bamboo hurdles, at the apex of the V, an opening is left against which a trap is set. In this case even if the flow of the main current is not very rapid the shape of the construction creates an artificial rapid and the fish are effectively trapped. In South Canara and Chota Nagpur, a sloping platform of split bamboo matting with its lower margin slightly folded is fixed at the opening in a dam, so that the discharge is narrowed down towards the lower end against which a cage trap is set and the water flowing over the platform is automatically led into the trap.

(*b*) *Valved cages*

(*b1*) *Single-Valved Cages*:

(*b1'*) *Funnelled Cone Cage* (*Kunini*—Nagpur, Plate II, Fig. G): An improvement in the efficacy of the simple cone cage, both in the scope of catch and in ensuring the trapping, is achieved by the inclusion of a wide detachable splintery 'funnel' the tail end of which fits in telescopically into the mouth of the primary one. The flexible ends of splinters at this 'tail' project freely into the cone overhanging one another thus screening as a valve preventing the escape of fish once they are trapped in the cone. The 'cruives' such as the *Kuri* reported by Thomas (*op. cit.*) from the Canara district are allied to these traps, as also the *Kunjol* which is a crude type of the Kuri.

(*b1''*) *Aproned Cone Cage* (Plate II, Figs. F, E and H): Another modification of the simple cone cage for similar purposes is effected by the addition of a detachable fan shaped apron, one end of which is inserted into the open mouth of the cone. In some localities a rectangular bamboo mat reinforced by split bamboo pieces is used as an apron. Across the front margin of the mat a split bamboo piece is laced and two or three others at short intervals from the front margin. The inner margin of the mat is left free which enables the side to be folded into two and inserted into the mouth of the cone to form a narrow, slit shaped aperture. The dimensions of the mat vary according to the size of the trap to which they are fixed. Usually a trap $2\frac{1}{2}$ to 3 feet long and having a mouth of diameter of one foot has a mat $1\frac{3}{4}$ foot $\times$ 1 foot attached to it. The apron cone cage is used in Malabar, Coimbatore, the Garo Hills of Assam, etc.

In some cases the funnel or the apron may be fixed permanently to the cone and the whole contrivance in such cases often assumes large proportions.

In certain localities a different type of funnelled cone cage has the tail part (valve alone instead of the whole funnel, e.g., the Shillong fish cage used in Assam.[a] Numerous minor variations occur in constructional details of the valved cages in different localities and as it would be superfluous to describe those details, the photographs of some of them are given (Plate II, Figs. C, D and I). In the Travancore Cage Trap we have a combination of the apron and funnel with the cone cage.

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A slight modification in the structure of the valve is often incorporated in the cage traps. The opening of the valve instead of being central is sometimes eccentric in position being nearer to one side. This is effected by attaching bamboo splinters of unequal length all round the mouth opening of the trap so as to project inwards. The splinters on one side are smaller and gradually increase in length towards the other side. The arrangement renders the egress of the fish more difficult.

(*b1'''*) *Spindle Cage* (*Kalio ruh*—Assam, Plate V, Fig. H): As the name signifies, this is spindle-like in appearance. It is made of strong bamboo splinters. At one end the converging splinters are tied close together with a flexible strip of bamboo or cane. At the other end the splinter ends are tied on to a plug of wood or bamboo. The trap is strengthened by flexible strip of cane encircling it at intervals. On one side of the belly, the trap has a rectangular opening guarded by a valve or an elliptical opening fixed with a small apron and funnel valve, made of bamboo strips. These traps are set with the valved opening facing the current in streams across which hurdles are constructed with bamboo poles as described earlier, with openings in the hurdles just large enough to accommodate the traps. The catches are removed by untying the plug end.

An ingenious modification of the spindle cage especially for use in tidal areas is the addition of a second door with apron and funnel valve on the opposite side. This two-way spindle cage (Plate IV, Fig. H) can function both in the high tide as well as in low tide through one or the other valve.

(*b2*) *Double Valved Cages*: This is one of the most efficacious of cage traps.

(*b2'*) *Goalpara Double Valved Cage* (Plate III, Fig. C): In shape it is roughly elliptical in cross-section and a foot and a quarter in length. The mouth opening, which is guarded by an eccentric valve as described above, is 12″ in diameter. At a distance of about 8 inches from the mouth opening is constructed another valve. Obviously this arrangement increases the trapping power of the contrivance. Often double valved traps are much larger in size sometimes, 6 to 12 feet in length. Three or even four valves may be provided as the length increases.

(*b2''*) *Parrot Cage Trap* (*Kribawans*—Uttar Pradesh, Plate IV, Fig. F): This is a highly specialized and complicated form of cage trap and is used in comparatively deeper flowing waters in the Uttar Pradesh. Made of bamboo or cane splinters, it has two compartments, a lower parallelepiped and an upper conical one. The apex of the upper chamber is tapering, where all the bamboo splints converge together and are tied with a jute rope or a flexible strip of cane. When this rope is loosened the whole upper portion opens up to facilitate the removal of the catch. The height of the entire trap is about 5 feet and the lower chamber is one foot high with a base $2' \times 2'$. Separating the two chambers is a partition consisting of a valve of fine long bamboo splinters which are fixed to the walls of the trap at the outer ends while their inner flexible ends are free and overlap, projecting centrally upwards into the upper chamber. The lower chamber has on one side a simple rectangular opening $1' \times 9''$, which is not guarded by a valve. A number of encircling lacings of jute rope are given and hoops of cane or bamboo are attached at intervals to strengthen the trap. The interstices between adjoining bamboo splinters is nearly a quarter of an inch. The trap is set vertically in comparatively deeper waters at openings in dams, or obstructions in streams raised for the purpose. Fish along with the current of water enter the basal chamber through the opening

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and are pushed into the upper chamber by the force of the current or in their attempts to escape from the trap. Once they get into the upper chamber they are entrapped there due to the presence of the valve. The catch is periodically removed without disturbing the trap by untying the cord at the top.

The types of fish caught in cage traps are chiefly *Anabas*, *Ophicephalus*, *Clarias*, carps, etc. Even unwary turtles sometimes find their way into some of these traps and are captured.

(iv) *Box Traps*—The group of traps which resemble the cage traps closely in their *modus operandi*, but are more highly specialized and in some cases better adapted for their purpose are what can be termed box traps, owing to their far-fetched resemblance to boxes. Generally these traps are parallelepiped in shape and made of fine bamboo or cane splinters. In some cases the corners of the parallelepiped are rounded. Some of these traps are of a simple make, while others have ingenious valve-like structures provided at the entrance. Most of these traps are provided with a detachable door-like structure at the top near the side away from the entrance. The traps are often used in identical environs as the cage traps, but are particularly suitable for use in streams, rivulets, channels and lakes where the water is comparatively still and devoid of currents. The magnitude of the damage caused by box traps to inland fisheries is comparable only to that resulting from cage traps when directed against fry and brood fish. Their application also is country-wide, and consequently the shapes and sizes they attain are innumerable. The more important and typical forms are described below:—

(*a*) *Simple Box Traps* (Plate III, Fig. D and Plate IV, Figs. D and E):

The Bengal box trap is a typical example of the simple box trap. This is a parallelepiped contrivance made of fine bamboo splinters laced together very closely with a fine jute cord, leaving narrow interstices measuring about $\frac{1}{10}''$. The base is about a foot in breadth and 20″ in length. The height of the trap is 17″. On one of the broad faces, the wall of the trap turns inwards to form a sort of groove, in which an opening about 5″ long and 2″ broad is left. The bamboo splinters forming the sides of the opening are very slender and flexible, with the result that fish bigger in size than the entrance can without difficulty force their entry by pressing on the yielding splinters, but because of the curved disposition of the groove in which the opening is situated, those trying to force an exit through it bring the splints nearer making the opening smaller and thus get trapped. These traps are used both with and without baits, the bait consisting generally of worms hung, tied to a string, across the cavity of the trap. In small streams and rivulets, long vertical screens of bamboo poles interlaced with strips of the same material are erected either in a straight line across the current or more often in the form of a V, as in the case of the cage traps. In straight hurdles, gaps are made for the traps to fit in. In the case of V shaped obstructions, the trap is fixed at an opening at the apex of the V. In comparatively still streams a number of straight hurdles are erected at some distance from one another. These hurdles do not extend across the entire length of the stream but occupy only a small distance in the middle. At either end of these hurdles a box trap is set in the form of a dumb-bell so that the hurdle abuts against the further wall of the entrance groove of each trap. When fish and prawns come in contact with the hurdle, instinctively swim along it and are finally led into the trap. Sometimes more than one groove and entrance are

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provided on the face while in certain box traps they are provided on both the broad sides.

Often in the Chilka Lake several box traps are operated in a cleverly set combination. Each trap is fixed by its closed broad side to a stout bamboo pole much longer than the height of the trap. A number of these traps are fixed to the substratum with the help of the poles and left submerged in water, side by side, in such a way as to enclose a rectangular area, with the opening of the traps facing into the enclosure. A small portion is left to serve as an entrance to the enclosure. Whereas the traps are submerged, parts of the bamboo poles tied to them will be projecting out of the water surface. In each of the traps are kept worms hung on a string. Crabs and fish getting into the enclosures are attracted by the bait and eventually get entrapped. Every evening the fishermen go to the site where the traps are set and lift them out of the water with the help of the bamboo poles. The catch is removed from a door provided at the top of each trap. Mostly crabs and occasionally small Threadfins and Jewfishes are caught in these traps.

(*b*) *Valved Box Traps*

(*b1*) *Valved Boxes with short Rectangular Openings* (Plate IV, Fig. G): These traps are identical to the ones described above, in general shape, the only difference being the provision of rectangular openings with regular valves near the base of one of the broader faces in the place of grooves and entrances located in them. These openings are guarded by a structure made of fine bamboo splinters attached at one end to the entrance, the other remaining free and over-lapping, not unlike the valves described under cage traps. The trap illustrated is about a foot high and 3 feet long, the width between the entrance side and the backwall being 8″. This has three entrances guarded by valves, but the number of entrances increase with the size of the trap.

(*b2*) *Valved Boxes with Longitudinal Openings* (Plate III, Figs. E and G): In general shape these traps resemble the ones described above. But, along the middle of one of the sides there is an elongated opening extending from top to bottom, similar to the entrance groove of the Simple Box Trap. The wall of the trap turns slightly inwards on each side of the opening, and almost in a line with this is tied a cord on either side. This cord is laced at intervals to short fine bamboo splints the ends of which are sharp and pointed. Thus on each side of the opening projects inwards, a converging screen of bamboo splinters, the inner ends of which are sharply pointed and inter-locking. This arrangement provides an easy inlet for the fish but renders their passage in the opposite direction impossible. Usually these traps are set in the same manner and in identical environs as the other box traps.

In the Chilka Lake a similar box trap known locally as 'Dhandi' (Plate III, Fig. G) is set in an ingenious manner (Plate V, Fig. B). In areas in the lake where the depth of water is about 4½ to 5 feet bamboo screens are erected in such a manner as to enclose a roughly equilateral triangular area. At each of the angles of the triangle the screens are not continuous but a gap of about 1½ feet is left. At each of these three gaps is set a box trap with the entrance facing the triangular enclosure. The traps are fixed to the substratum with the help of strong bamboo poles. Further, in the centre of the side of the screen forming the base of the triangle an opening about 3 to 4 feet wide is left serving as entrance into the triangular enclosure. On either side of the opening the screen is turned inwards up to a little distance as could be seen in the figure. From the centre of the

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opening outwards is set a long bamboo screen 100 to 200 yards long. Prawns have a peculiar habit of swimming along these screens once they come in contact with them, and as a result, when in their rambles in the lake they approach the screen they automatically find their way into the triangular enclosure and ultimately into the traps. The top wall of the trap remains above the water surface and on this wall is provided a small door-like contrivance. Fishermen come on their boats every evening to these traps and remove the catch through these doors. In the peak of the prawn season these traps get filled in a few hours so that the fishermen have to repeat their visits four or five times a day. These traps are operated from March to June, and very heavy catches of prawns are collected every day from each trap. Crabs and fish are also caught occasionally.

(*b3*) *Hut Boxes* (Plate V, Figs. C and D): These are in vogue mostly in Bengal, Bihar and Orissa. The main difference in these traps from the other Valved Boxes is that it is five-sided, the top ends of the splinters of the four sides from the rectangular base being tied to a bar which forms the top beam, as it were, of the 'hut'. In the Chilka Lake hut boxes are used for catching prawns. The hut box is a strong contrivance about 3½ feet high and 4 feet long made of bamboo splints, and stands upright on a long narrow base, 8″ wide and slightly rounded at each end. The sides that rise from the base are strengthened by strong bamboo bars, laced at intervals with jute or coir cord. The top of the trap is ridge-shaped, the sides being brought together and tied to a long bar of split bamboo, except for a short distance at one end, where the sides are tightly laced together, so that by pulling the lacings the sides there open apart to allow the entrapped prawns or fish to be removed. On one of the broad sides, a short distance above the base are situated three or four rectangular or semicircular openings, guarded by converging and inwardly projecting bamboo splints which act like a valve allowing the prawns to enter but not to get out. The openings are usually 7″×3″. Sometimes an additional row of openings are provided above the basal row.

These traps are set in the Chilka Lake where the depth of water is 3 to 4 feet, the size of the traps used being directly proportional to the depth of water. The traps are set in the water partly submerged, the open entrances being invariably kept under the surface level. They are fixed to the substratum with strong bamboo poles set crosswise. Seven to eight traps are closely set side by side to enclose a roughly circular area of water with the entrance sides facing the enclosure (Plate V, Fig. A). A gap about two feet wide is left to serve as an entrance to the circular enclosure. From the centre of this gap, extending outwards is a straight bamboo screen 200 to 300 yards long. Prawns swimming in the lake, when they come in contact with the screen swim along it and are eventually led into the circular enclosure from where they ultimately get captured in the traps. These traps are also set from March to July, and the daily catch of these traps often amounts to several maunds.

There are various other varieties of box traps similar in principle but differing in shape from those described above. The Triangular Box Trap of Chittagong (Plate IV, Fig. A) without valves and the Bell Trap of Nagpur (Plate IV, Fig. B) with a valve, are instances. A Stellate Trap made of split bamboo or babul basketry with four or five entrances guarded by valves leading into a common central chamber is described by Hornell. Such traps are used in the shallow areas of the sea amidst coral reefs. These traps are baited with worms, and are anchored in the shallows and several varieties of rock perches and other sea fish are caught in them.

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5. Miscellaneous Trapping Devices and Snares.—In addition to the various methods of trapping described above, there are a number of miscellaneous devices, though generally of limited use.

(i) *Sleeve Traps*—The principle involved in the use of sleeve traps is based on the habits of murrels, eels and allied fishes, seeking crevices and holes either for shelter or for egg-laying. The chief sleeve traps are:

(*a*) *Tube Trap*: A single long inter-node of a thick bamboo, open at one end and closed at the other by an inter-nodal partition is termed a *chunga*. Several of these are set near the banks of a tank or a sluggish stream and left there for a number of days. At intervals of a couple of days the fisherman goes to the spot where the *chunga* is fixed and lifts it out of water with the open end closed by the palm. More often than not he is rewarded with a catch. The spiny eel, *Mastacembelus* is frequently caught this way.

(*b*) *Vessel Trap* (Khan, 1930): Unserviceable earthen or metallic pots are often used for catching fish in many parts of the country. When left in the shallow areas of tanks and swamps, fish like *Clarias* and *Heteropneustes* enter these vessels, spawn and remain inside, guarding the eggs. An additional attraction is often offered by placing some rice or wheat flour made into small pellets in the vessel. Sometimes the mouth of the vessel is closed by tying a piece of cloth over it with a small hole in the middle. The whole pot thus prepared is kept immersed in water in small streams or ponds. Fish attracted by the bait enter the vessel through the hole provided in the cloth. The pot is gently lifted from time to time and the fish are collected. Only small fish could be caught by this method which is commonly employed by the hill-tribes in various parts of the country.

(*c*) *Apposed Hollows*: An almost similar device called '*oli*' is in use in various parts of Malabar, to catch *Etroplus suratensis* during breeding season in August and September. *Oli* is a simple device made by fixing two of the broad basal petiolar ends of coconut leaves (cut to a length of 1 to 1½ feet from the base) with their inner concave surfaces facing each other, thus enclosing a hollow space. A number of these *olis* are set in submerged paddy-fields or other shallow areas where the fish are known to frequent. *E. surantensis* which is in the habit of selecting protected spots for spawning selects these cavities and lays its eggs. After the eggs are laid both the parent fish keep guard over the eggs and hence necessarily remain in the *oli*. At suitable intervals the fisherman locates the *oli*, covers it with a cover basket and captures the fish. This practice is harmful in that large number of eggs and immature fish are captured this way.

(*d*) *Murrel Noose*: A lightly modified form of the tube trap, similar in principle but made of different material, is what is known as the Murrel Noose. Here the tube is made of palmyrah fibre or grass, woven in double ply into a rough mesh-work of open netting with a wide mouth, narrowing gradually to a blind end. It is usually 14″ to 20″ in length, with a mouth diameter of about 8″ to 10″. It is fixed usually in the evenings near shallower parts of the streams, canals or swamps where murrels are known to breed. Generally one murrel gets caught in each noose. The use of this device is harmful in that ripe females are usually caught and thus whole broods are destroyed. However, as long as the catches are solitary the injury is limited. Besides wherever the murrel, as a predaceous enemy in fish farms, is to be removed the noose is of positive advantage. A similar device in use in the Hyderabad State is referred to as *the Chikkam*.

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(ii) *Baited Float*—A device much simpler than the above is used in some parts of southern India to catch prawns as mentioned by John (1936). This unique device which may be termed the floating bait, consists of a length of thin strong string, to one end of which is tied the visceral mass of a snail and to the other a small float. These devices are used from June to October in shallow inundated areas where prawns collect to deposit their eggs. A number of these contrivances are set afloat in a small area of water and the fisherman waits nearby on a small canoe with a cover basket. Prawns attracted by the baits, collect in the area and start nibbling at the baits and consequently set the float in a sort of up and down motion. The fisherman quietly approaches the moving float and covers it neatly with a cover basket, thus entrapping the prawn which is subsequently removed by hand. Though this method appears to be slow and tedious, it is said that in the best part of the prawn season a few hundreds of prawns could be collected in two to three hours.

(iii) *The Batchwa Trap—Baited Pole—Pseudeutropius garua* is caught in a very interesting manner in some parts of northern India as mentioned by Faruqui and Sahai (1943). Small fish are kept in a vessel and are allowed to decompose, when they start giving a foul smell, they are tied at the ends of long cords. A number of these cords with baits attached are later tied to bamboo poles fixed in water in such a way that the poles project three or four feet above the water level. The baits are thus kept hanging in the water. These poles with baits attached are fixed usually in areas where *batchwa* are known to abound. The smell of the decomposing baits attracts the fish in large numbers which come to feed on them. When the fisherman feels that sufficient number of fish have collected, he approaches the spot by quietly wading through water and throws a cast net and collects the fish.

(iv) *Fish Bone and Bait*—In freshwaters of Bihar, a primitive but very interesting practice of fishing is indulged in. Heads of the Hilsa fish are allowed to rot. When they start emitting a foul odour, they are ready for use. Two strong vertebrae of Hilsa fish are tied, one at each end of a yard long string. With this equipment each fisherman sets out on a small canoe in the river. At a suitable spot he starts the operations. With one hand he holds the rotten head of Hilsa under water. Fishes slowly collect round the foul-smelling head. With the other hand the fisherman plunges the vertebrae into the water holding the string at mid-length. As the fish try to nibble at the vertebrae the fisherman deftly lifts them out and gathers the fish into the boat. Only small fish measuring about 4 to 5 inches are caught in this way.

(v) *Baited Spring*—A very ingenious contrivance commonly used in the paddy-fields and other inundated areas of the Indo-Gangetic region is the Baited Spring referred to by Hornell (1924). It is known locally by various names like *Barra*, *Kaibarsa* and *Datia*.

The entire device consists of a cylindrical float made from a joint of *nal* reed. A short fine cord is tied to the middle of the float at one end and at the other to a strong flexible splint of bamboo sharp and pointed at the extremities. In operation the two ends of the bamboo splint are delicately adjusted within the strong chitinous body of an insect—usually a grass-hopper—which serves as a bait. Hundreds of these devices are set afloat in the paddy fields. When an unsuspecting fish attracted by the tempting bait tries to seize it, the ends of the bent bamboo splint spring apart within the mouth or throat of the fish, making it impossible for the fish to get rid of it. The baits generally used are small frogs, cockroaches and grasshoppers. These snares are usually set afloat in the evening and the victims

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are collected next morning. The fish generally caught by this method are the Murrel and the Anabas. Writing about this method of fishing, Hornell observes 'this device is probably a modification of the gorge, a product of man's ingenuity dating back probably to Paleolithic age, for if this be the case, we have here a survivor in a modified form of the progenitor of the fishing hook'.

(vi) *The Light Trap* (Khan, 1930)—In small streams and canals a very interesting method of fishing is in vogue in various parts of the Punjab. During the months of March, April and May fishermen select a place in streams near the banks, where a lot of cowdung and rubbish are lying. Not far from such a place they fix a tripod stand of bamboos in the bed of the stream. On the top of the stand a small oil lamp complete with wick, oil, etc., is placed. During the night the lamp is lighted and consequently insects like flies, moths, etc., from the rubbish and cowdung on the bank are attracted towards the lamp. When they fly about near the flame their wings get burnt and they fall into the stream and are carried down the current. Fish finding delicious bits of food floating about are attracted to the place from where they are coming. As a result a number of fish collect near about the tripod stand and are ultimately caught with cast nets.

(vii) *The Cradle Trap* (Wilson, H. C., 1920)—Cradle traps are used widely in Moyar river. The entire trap is shaped like a large cradle with the end opposite the hood knocked out. The trap is set firmly in a level with the bed of the river, and the hood end is supported on stout stakes a few feet above water level. Cradle traps are set usually at places where islands occur in the rivers, and the cradles are set in such a way that one of the sides of the trap is made fast to the island, while from the other side runs a hurdle to the opposite bank to prevent the fish passing as well as to lead them into the trap.

(viii) *The Float Nets* (John, C. C., 1936)—The float net recorded by John (*op. cit.*) is an ingenious device used generally to catch *Etroplus maculatus* in Travancore—and is locally known as the *Uri-vala*. The whole contrivance consists of a piece of close meshed net about 2 to 3 feet square. To each of the four corners of the net is fastened a piece of coir thread or cord, the free ends of which are tied to a large piece of pith which acts as a float and keeps the net suspended in water. In operation some paste of rice bran made into small pellets is placed in the centre of the net to act as a bait and then the net is thrown into the water of a tank or a pond or even backwater stretches at a convenient distance from the bank. The fisherman sits on the bank with a bamboo pole long enough to reach the net. Fish attracted by the bait come to the spot where the baits are laid and linger there for some time. From time to time the net is lifted vigorously at the end of the bamboo pole and the fish are caught. Usually three to four fish are caught at a time in one net.

The elaborate and highly efficient Chinese dip net works more or less on the same principle though, but for a burning hurricane lamp at night no bait is usually used for snaring the fish.

Discussion

A general survey of the fish traps and trapping methods in vogue in various parts of the country reveals that there is a striking similarity between the various devices used in the different parts and in their *modus operandi*. The diverse tribes which live in their inaccessible retreats on the tops of

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hills and in the recesses of forests completely shut off from the surrounding world, also use amazingly identical types of devices.

Fishing by hand presumably the most primitive type of fishing is indulged in, by most of the tribes. To give but a few instances: the *Nagas* of Manipur wade in small pools, and drive the fish into shallow areas with the help of nets attached to long bamboo poles—where they catch the fish with bare hands, or hand nets. The *Thadou Kukis* of Assam get into and puddle shallow areas of water, and then catch fish with hands. The *Lhota Nagas* similarly catch fish with hands in branches of streams after cutting them off from the main current by erecting dams. Fish lurking in cracks and holes on the banks and muddy streams are also caught by hand. They also dive into rivers when the latter are in spate and muddy, during rainy season, and catch fish with bare hands, without any sort of aid. Similarly fishing with hands is in practice in various parts of Bengal and Bihar. The *Balahis* of C.P. catch fish with hands in small rivulets, *nalas*, and inundated fields, after daming and draining off the water. The *Marias* and *Baigas* of C.P. the *Veddahs* of Ceylon and the Nicobar Islanders are also known to use similar methods. Constructing dams and weirs with mud and bamboo stakes for setting basket traps is a practice which is also resorted to by various tribes throughout India.

The cover baskets used in different parts of the country also bear a great resemblance to one another, in shape and structure. The *Muchu* and *Chappa* used by *Kharias* and *Baigas* respectively in C.P. The *Uduka* and *Irable* used by *Bestas* of Mysore, the *Ottalu* used by *Pulayas* of Travancore, the *Poluha* used in Orissa and *Palha* used by *Kacharis*, have all a shape roughly identical to one another. The *Polo* used in Bengal and *Tsooung* of Madras though operated on the same principle as others, differ slightly in shape.

Among simple cage traps, without valves, the *Kannillatha kurti* of Malabar, the *Chekwe* and *Asok* of the Garos in Assam, the *Londra* and *Chuludoe* of *Kharias* of Bihar, the *Bisar Dundka* of *Marias*, *Bissera* and *Jhitka* of *Baigas* of C.P. and the cage traps of *Veddahs* are all identical in shape and structure.

Cage traps with detachable funnels are used in Malabar and identical ones are made by *Purams* of Manipur and are called *Rupi*. The *Naching* of *Lhota Nagas* is another instance of a similar type.

Instances of similarity are likewise found in box traps and other trapping devices also.

Traps avowedly are the most primitive devices evolved by man, before the impact of modern civilization, and amongst these the inland trapping methods are doubtless the most ancient. Hence the presence of identical devices among tribes who are isolated from one another leads to the inference and supports the view that long before the advent of extraneous races there existed in India a people with close cultural contacts freely intermixing with one another. After the influxes of foreign races such of these indigenous people who refused to submit to and associate with, the invaders or those who due to other reasons did not come in contact with them, have retired to isolated places to live their lives uninfluenced by the foreign impact and those probably are the tribal people of today.

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Explanation of Plates

Plate I

(A) Cover basket. *Poluha*—Orissa.
(B) do. *Tsoung*—Madras.
(C) do. *Polo*—Bengal.
(D) A cover basket in operation.
(E) Cover basket. *Udaka*—Mysore.
(F) Platform-cum-Bush trap. *Chattam*—Malabar. (Model).
(G) Bamboo screen used for trapping fish.
(H) Eel cage. *Aaralkoodu*—Malabar.

Plate II

(A) Monk's hood scoop. *Ocha*—Bengal.
(B) Semifixed scoop. *Dunre*—Bengal.
(C) Cage trap with valve. Assam.
(D) do. Bengal.
(E) Aproned cone cage. Malabar.
(F) Front view of the above.
(G) Funnelled cone cage. Chota Nagpur.
(H) Aproned cone cage. Assam.
(I) Cage trap with valve. Bombay.

Plate III

(A) Simple cone cage. Madhya Pradesh.
(B) A basket used for storing fish. Bengal.
(C) Goalpara double valved cage. Assam.
(D) Simple box trap. Bengal.
(E) Box trap with valve. Bengal.
(F) do.
(G) do. Orissa.

Plate IV

(A) Triangular Box trap. Bengal.
(B) The Bell trap. Madhya Pradesh.
(C) 'V' shaped bamboo hurdles, for setting traps.
(D) Simple Box trap. Orissa.
(E) do.
(F) Parrot cage trap. Uttar Pradesh.
(G) Box traps with rectangular openings.
(H) Two-way spindle cage. Assam.

Plate V

(A) 'Hut boxes' in operation in Chilka Lake.
(B) Box traps in operation in Chilka Lake.
(C) 'Hut box' trap. Orissa.
(D) do.
(E) Box trap with valve. Orissa.
(F) Mattress—bush-hold being carried on a boat. Assam.
(G) Mattress—bush-hold in operation.
(H) Single valved spindle cage. Assam.

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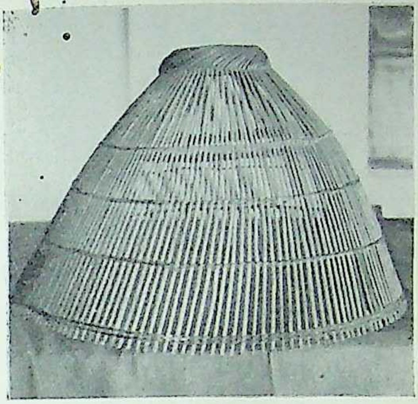
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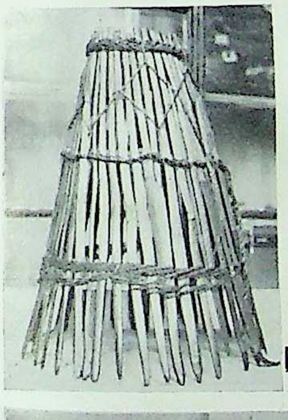
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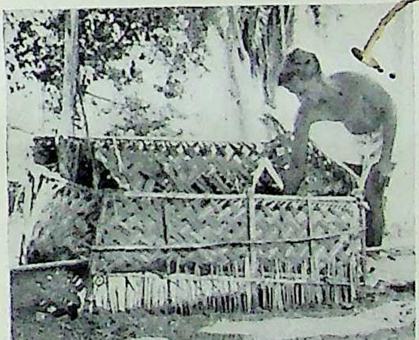
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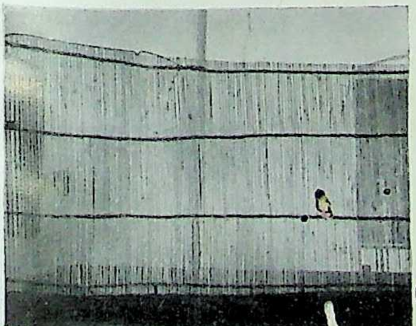
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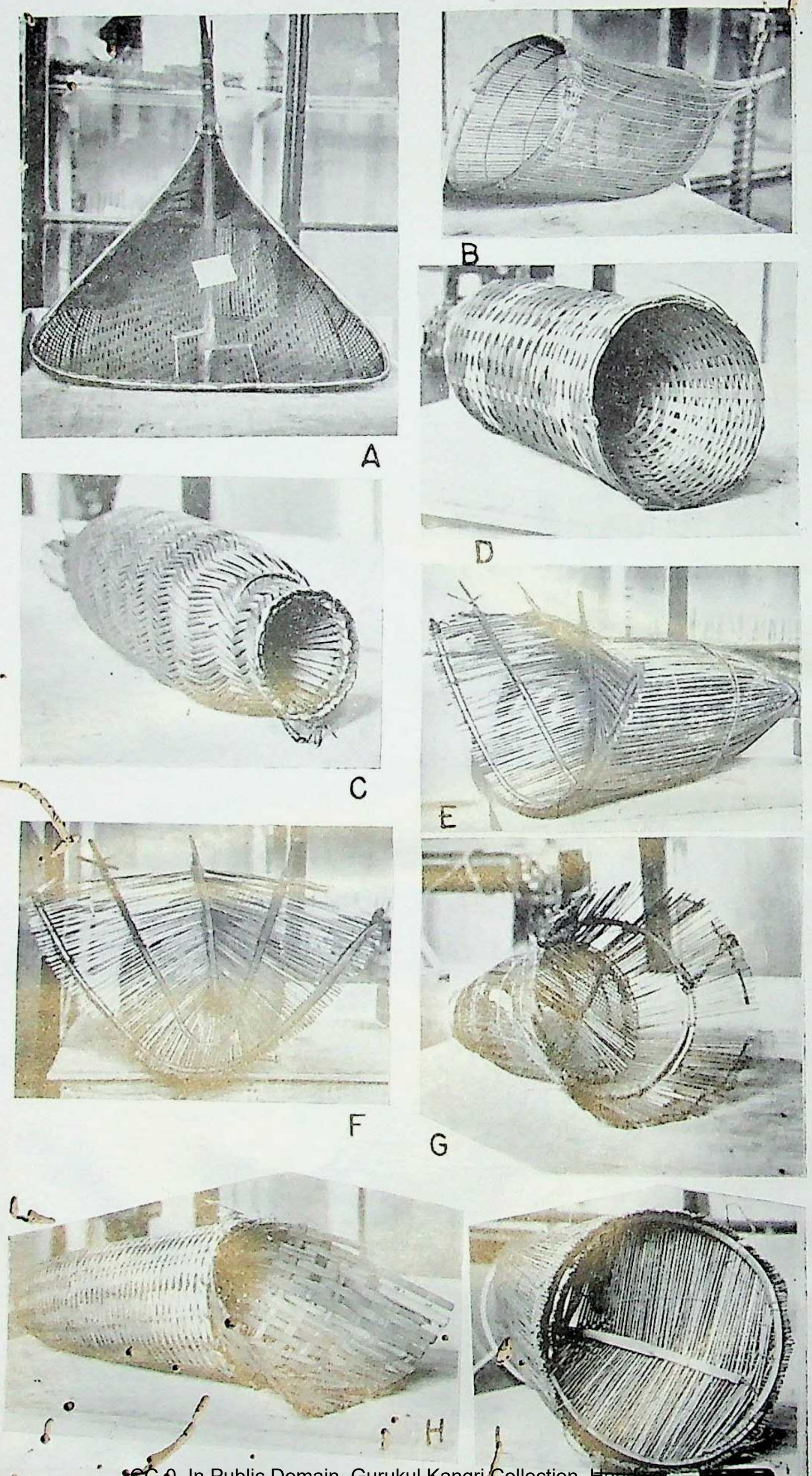

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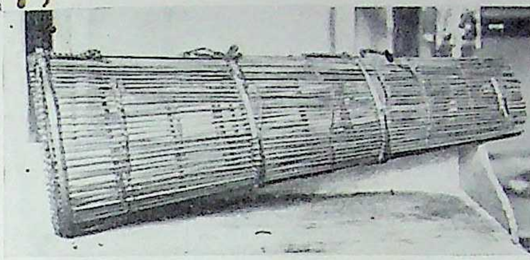

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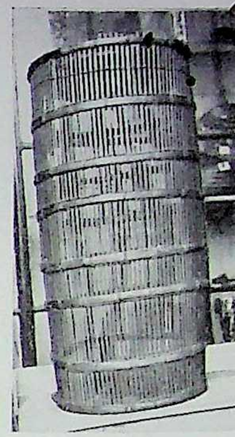

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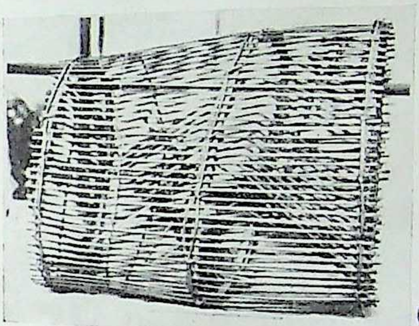

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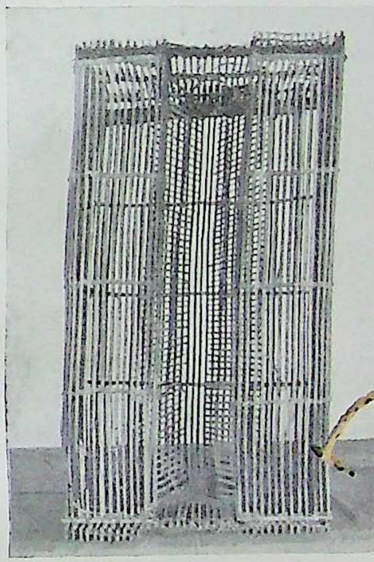

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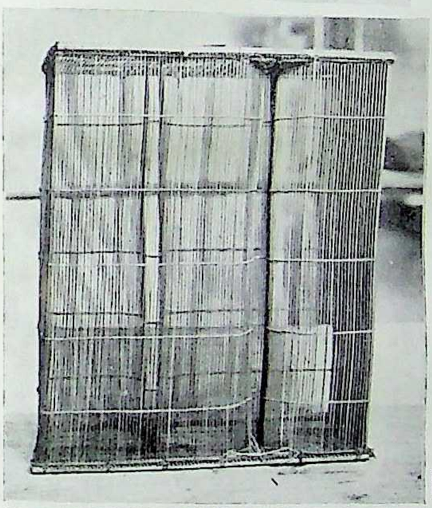

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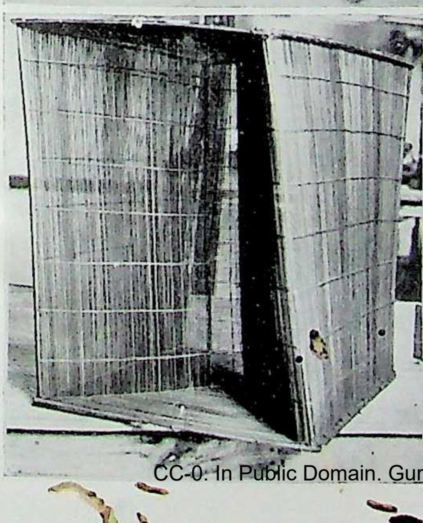

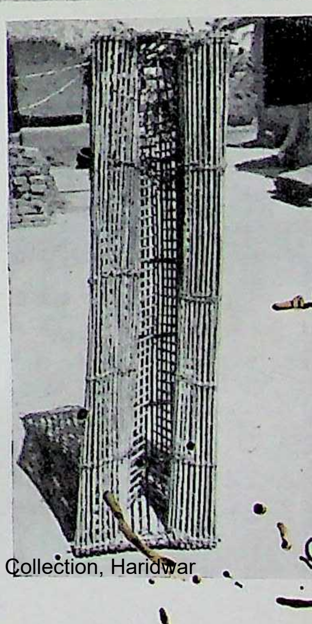

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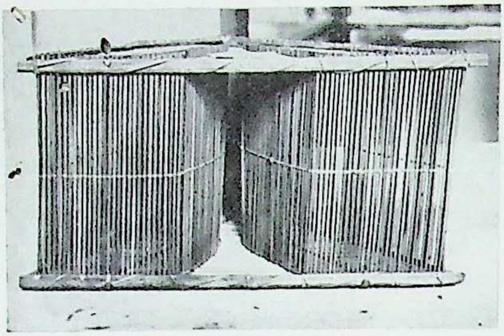

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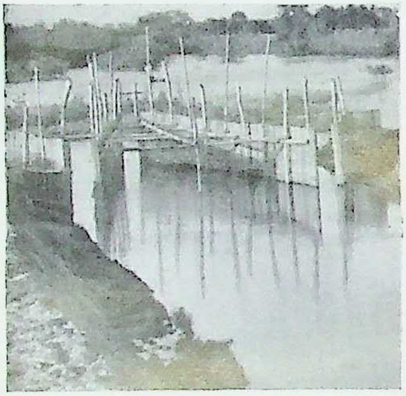

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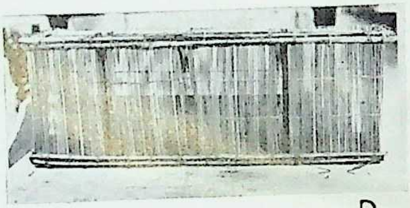

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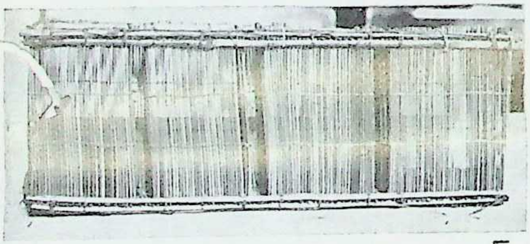

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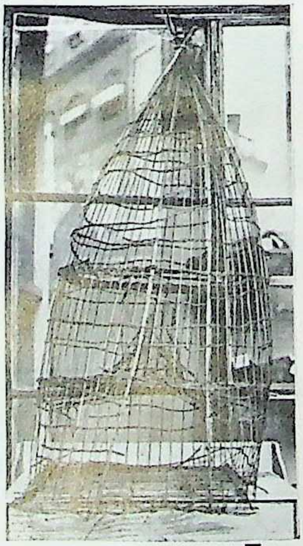

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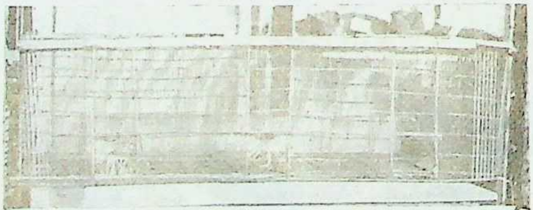

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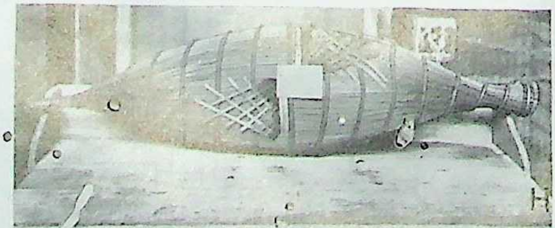

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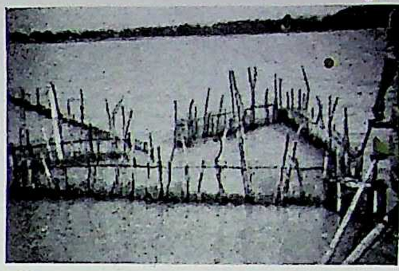
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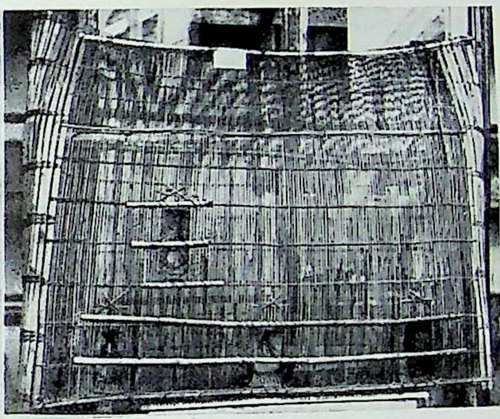
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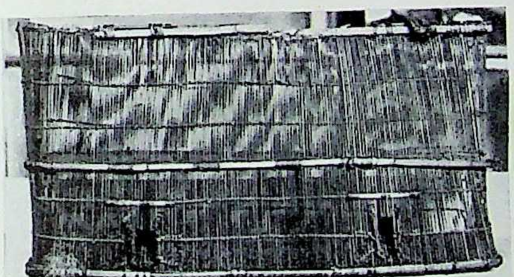
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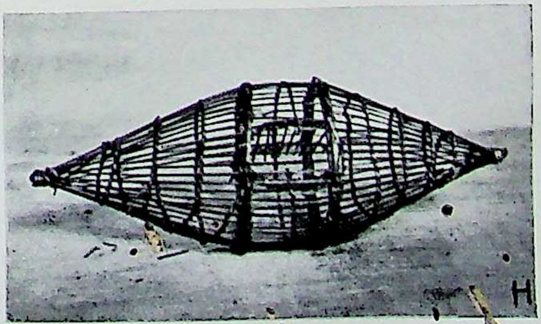
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NOTES ON THE BIONOMICS AND SOME EARLY STAGES OF THE MAHANADI MAHSEER *

By A. David

(*Paper received on 27th August, 1952*)

(Communicated by Dr. S. L. Hora)

Contents

Introduction

In the course of fishery investigations, a new race of the Mosal Mahseer, *Barbus* (*Tor*) *mosal mahanadicus*, was found to be one of the major carps distributed in the Hirakud Dam Section of the Mahanadi river. The varietal name *mahanadicus* is now proposed for this Mosal, which differs mainly in the following respects from the *forma typica* :—

Barbus (*Tor*) *mosal mahanadicus* nov.	*Barbus* (*Tor*) *mosal* (Hamilton)
Length of head often more than depth of body.	Length of head equals depth of body.
Eye 4·5–7 in length of head.	Eye 3·3–4·2 in length of head.
Back iridescent greenish yellow, sides silvery, abdomen milk white; a light grey band from opercle to base of caudal. Dorsal fin invariably green or blue, other fins yellow or orange without spots.	Colour more yellow than gold, dorsal fin reddish orange; other fins orange yellow.

(For a detailed description of this new variety, attention is invited to a paper by the author.—1953.)

The present paper is based on monthly fish collections and related biological observations extending from January to August 1949, and at various intervals thereafter till January 1951. Well-grown specimens of over 207 mm. in length, that were found in collections of fish made both above and below the Dam site (sketch map 1) were utilized for this study. Stages in the development of the gonads, together with the sizes and weights of this Mahseer were recorded from time to time along with those of other major fishes. By a noticeable absence of the fry of this fish during

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the S.W. monsoon and the fact of its young having been earlier obtained close to Dhama in February 1949, it was presumed that it breeds in the Mahanadi sometime in winter. As a number of stray fry ranging between 18 and 35 mm. in length were available again in December 1949, in the same region, a systematic search for the young was made in the river stretch close to the Huma village temple sanctuary where hundreds of adult Mahseers generally shoal together (sketch maps 1 and 2 and photograph 3 in plate I), and shoals of fry of this fish were located in the shallower marginal pools between Huma and Dhama villages. A number of gravid specimens were also examined from this region and hundreds of fry and post-larvae were collected in the winters of 1949-50 and 1950-51. As gravid adults of both sexes could not be secured simultaneously for artificial fertilization, experiments in this direction were not successful. Developing eggs and early larval stages could not be examined.

During the course of observations 65 juveniles and adults ranging between 207 and 720 mm. were examined. Besides, examples up to a total length of about 1,200 mm. (45″) that were being sold in Sambalpur fish-market yielded additional and confirmatory information about the seasonal variations exhibited by the gonads. Post-larval stages and fry were collected by spawn nets or by dragging rectangular pieces of thin cloth improvised as seines. Mahseer post-larvae and fry were greatly mixed up with those of minnow carps, *viz.*, *Barilius barila*, *B. bendelisis* and *Aspidoparia morar*. With a view to readily separate these latter from the former, a series of each of these species was collected for comparison. Post-larvae of Mahseer were stained in alizarin for confirmation of their identity from vertebral counts, fin rays, etc.

Many observers, (Day, 1873; Beavan, 1877; Dunsford, 1911; Nevill, 1915; Skene-Dhu, 1918; and Khan, 1939) were of the opinion that Mahseers bred several times in a year including the monsoon months. Thomas (1897) found them breeding at intervals during post-monsoon months. Hora and Mukerji (1936) and Hora (1939 and 1940) believed that *Barbus* (*Tor*) *putitora*, *B.* (*tor*) *tor* and *B.* (*Tor*) *mosal* bred sometime in August-September judging by the sizes of the young collected from Eastern Doons and elsewhere in the Himalayan rivers. Hora and Misra (1938) surmised that *B.* (*Tor*) *khudree* bred sometime in August-September in Deolali Hills, in the young of which they invariably found black caudal spots. Skene-Dhu (1918) collected yolked larvae and fry of a Mahseer with caudal spots in July. Beyond these, little else is recorded of even the post-larval stages of any *Tor* Mahseer.

Topography and Hydrographical Features of the Observation Grounds

A large number of post-larvae was obtained in the left arm of the Mahanadi surrounding Thavarkud Island about a mile below the Huma sanctuary. Both arms reunite near Dhama as shown in sketch map 1, but in dry months the water level is so low in the river, that these arms are no more than narrow channels merging only about two miles below the village. The river-bed which in this section is nearly two miles wide is a sandy waste during dry months except for the two narrow streams. The bottom of the channels is either sandy or rocky, or in many places, contains both.

Tracing the occurrence of the fry upwards from Dhama, it was observed that besides being available in isolated and connected pools along the right margin (sketch map 2), fry of various sizes and post-larvae of

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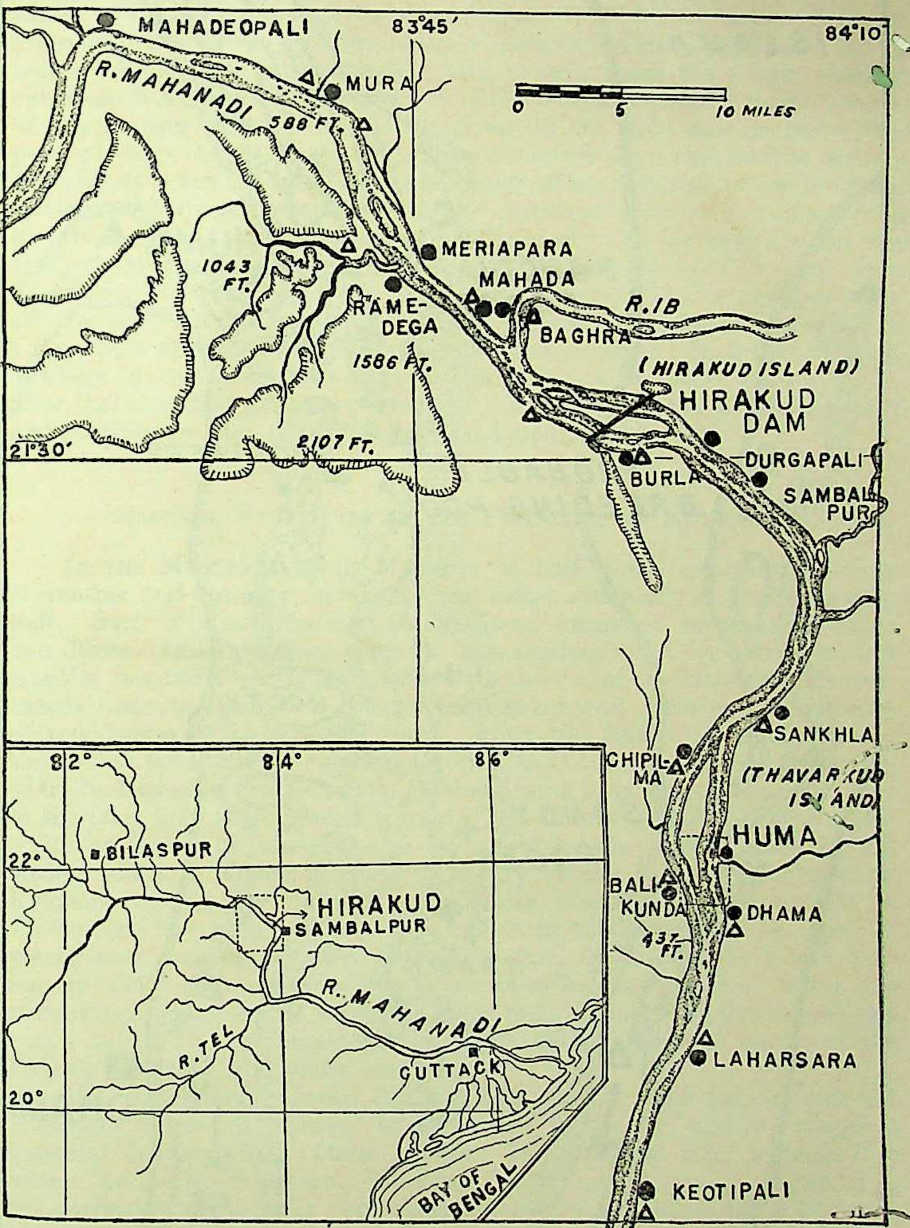

Sketch Map 1.

Showing the Hirakud Dam site and places on the Mahanadi River where adult Mosal Mahseers were collected—(●). Places where fry were collected are indicated thus—(△). Width of the river is not according to scale.

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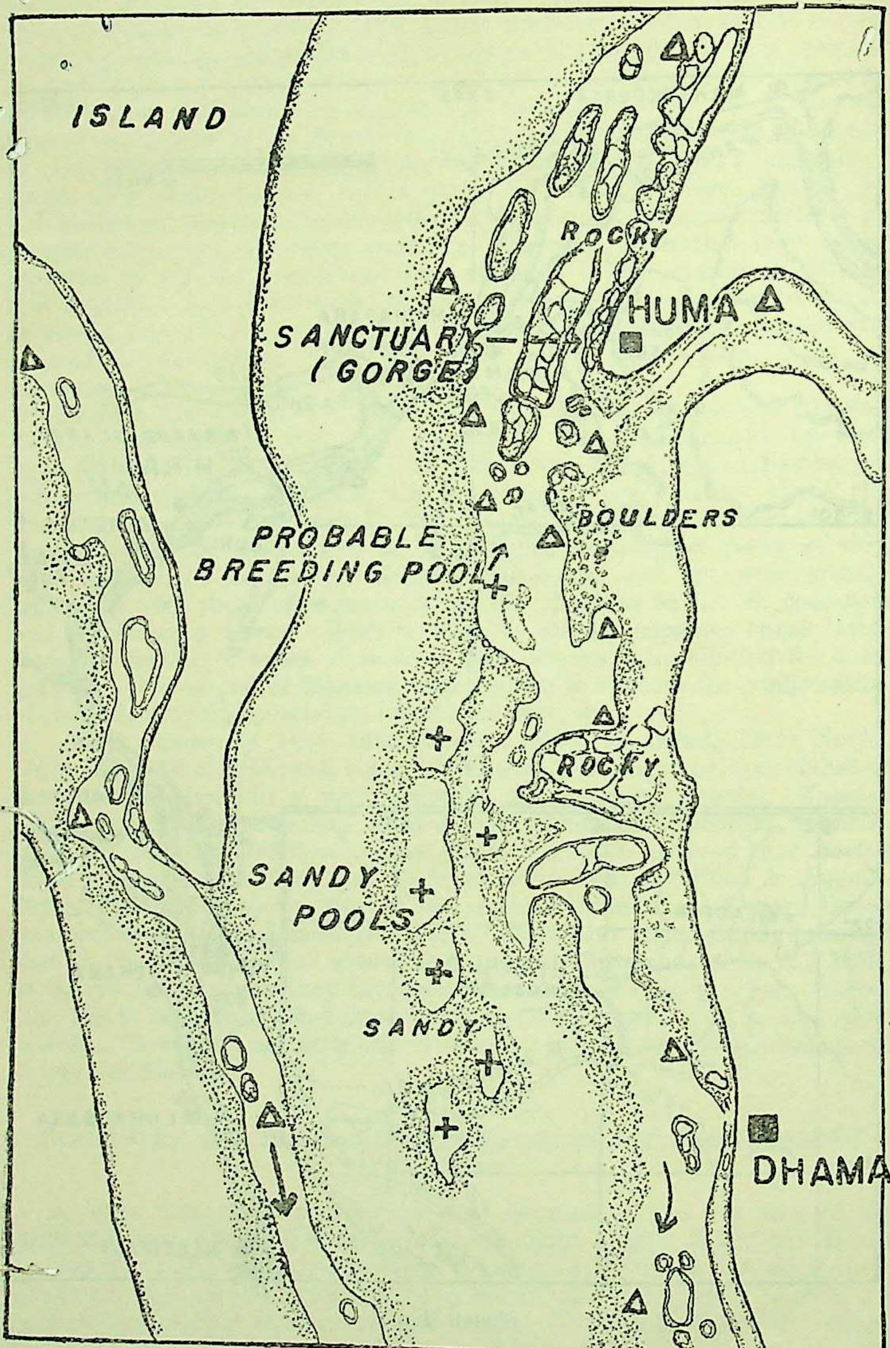

Sketch Map 2.

Enlarged sketch of the Mahanadi River between Huma and Dhama villages where large numbers of fry were obtained. Probable location of the breeding pool is also indicated. Places of fry collection are indicated by (+) and those where none were found by (Δ).

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10·4 to 15 mm. were found at the edge of the main stream leading to a large 2-acre pool shown in sketch map 2. In December 1949 and November 1950, this pool had an average depth of 6–8 ft. There was only a gentle flow at the time and the bottom was covered by fine sand. A major bifurcation above this pool was in direct line with the Huma sanctuary nearly half a mile on the upstream side. This branch being the deeper channel cut through a gorge on the right side of the temple, carried a major volume of fast flowing water which slowed down on the right margin below this pool, giving a chance to the drifting larvae or fry from this pool to become distributed in the marginal channels taking off immediately below it which, however, dry up in November with the quick reduction of flow of water in the river. It was common to see hundreds of dying or dead fry on wet sand along these branching channels. Strangely enough no fry were observed for a distance of two miles above this pool and in the sanctuary area for at least three miles along the left margin. At various points within a sixty-mile stretch which were under close observation, the fry were found nowhere in such abundance as near Huma. It is therefore reasonable to infer that breeding grounds are within the vicinity of the sanctuary itself and possibly, in and around the large pool mentioned earlier.

Seasonal Variations in the Condition of Sex-organs

In the Mahanadi, adult Mahseers of both sexes examined between November and January, invariably had either ova ready to shed or oozing milt. Such was not the case in specimens examined between February and June. This fact along with the non-availability of fry except in cold months, is a fairly conclusive evidence to show that the Mahanadi Mahseer breeds after the monsoon between November and January. Occurrence of post-larvae of 14 mm. in length during the first week of November, shows that spawning may commence even in October. The preponderance of fry in December makes it probable that a peak spawning period may occur in the later half of November. In *B.* (*Tor*) *khudree* and *B* (*Tor*) *mussullah* a similar spawning takes place as evidenced by the occurrence of fry and oozing adults in November in the Cauvery system in the colder months. Evidence of *B.* (*Tor*) *khudree malabaricus* breeding in cold months in Travancore has been collected by Jones[1] in the occurrence in April of young ones ranging between 42 and 60 mm. in length. It would thus appear that optimum conditions for breeding are reached when the temperature is agreeable as in the snow melted waters of the Himalayan rivers during the hot months, or as in the relatively cooler waters of the Deccan Plateau in the winter months.

Male specimens between 335 and 530 mm. in total length from the Mahanadi River in February to June were in the 2nd and 3rd stages of gonadial development. Those between 147 and 300 mm. examined in winter were still immature. Those above 380 mm. in length examined in the corresponding months were alone mature but not those below 350 mm.

Females from the Mahanadi between 426 to 615 mm. in length, examined between February and May, were in the 2nd and 3rd stages of ovarian development. In December 1949, females between 480 and 710 mm. in length were gravid, but not those below this length. It is therefore possible that in the Mahanadi, males and females of the Mahseer above 370 mm. and 480 mm. in length respectively attain maturity.

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[1] Hora, S. L., *Rec. Ind. Mus.*, XLIII, 247 (19[illegible]).

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From regular records kept of the gonadial condition in both sexes, it is observed that 2nd and 3rd stages of gonads alone occur between February and May and that there is no visible change in size of sex-organs during this period. Nevill (*op. cit.*) and Khan (*op. cit.*) have referred to this condition as 'well developed', probably because of the distinctness of the ova. Generally, carps due to spawn in monsoon months have their ovaries developed just prior to the commencement of monsoon rains. After shedding their ova completely in the rainy season, they remain in the spent condition. All this takes place within a short space of three to four months. In this connection measurements of ova from two gravid examples of Mahanadi Mahseer, revealed the following well-defined sizes which fall into several groups.

Specimen obtained on 4th January, 1950.	Specimen obtained on 10th January, 1950.
(in millimetres)	
2·34–2·43—soft ova.	2·43—soft ova.
2·07–2·16	. .
1·17–1·26	1·44–1·53
0·99–1·08	1·08–1·17
0·81–0·90	0·90
0·63–0·72	0·63–0·72
0·5 (approximate)	0·5 (approximate)
0·3 (approximate)	0·3 (approximate)
0·2 (approximate)	0·2 (approximate)
0·14 (approximate)	0·14 (approximate)

There is a wide gap of nearly one millimetre in the size of ova of categories 2·07–2·16 and of 1·17–1·26 mm. and of 2·43 and 1·44–1·53 mm. in the two examples. It is probable that this species has an extended period of gonadial development with the well-grown ova present throughout the year. Once the breeding season is over it is likely that the unshed ova remain more or less at the same state of growth till the ensuing season. It is obvious from the above that the several sizes of ova present may be termed as being in 'batches' and therefore likely to be exuded in a gradual manner as indicated by the observations made by Thomas (*op. cit.*). Range of water temperature in the river was between 72 and 83°F. during winter. Hence, a lowering of water temperature appears to have a great influence upon breeding of this fish.

Any evidence of scooping of sand[1] for deposition of ova as described by Thomas (*op. cit.*) was not forthcoming with reference to the Mahanadi Mahseer. Frayed fins were not observed amongst the hundreds of adults shoaling in the sanctuaries or those available elsewhere which were in many cases fully ripe and exuding. Although no actual process of spawning was observed, milting males and oozing females were found throughout the cold months. Fishermen also were not aware of any particular spawning habits of this fish, such as scooping of sand and so on. Female specimens that were being captured by the fishermen in the early hours of winter mornings were, however, reported to be in the habit of exuding a large amount of soft ova.

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[1] It is possible that the species of Mahseer described by Thomas is an inhabitant of South Indian rivers and very likely be Khudree Mahseer. The author has observed depressions caused by the breeding Mahseers in the Kabbani River in Mysore. Each depression which generally gets exposed as the water goes down, is locally known as a 'Thippe' in Kannada. It is generally 4–6 ft. in diameter being round or semi-oval in shape and 1½ ft. deep.

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POST-LARVAE

10·4 mm. Stage. (Text-fig. 1*a*.)	15·0 mm. Stage. (Text-fig. 1*b*.)	23·0 mm. Stage. (Text-fig. 2*a*.)	35·0 mm. Stage. (Text-fig. 2*b*.)
Body slender, gently tapering. Remnant of median and pre-anal fin-folds. Dorsal with 1 unbranched and 9 branched rays, anal with 6 and caudal (which is slightly forked) with 21 rays. No rays on pectoral fins; pelvics present only as buds.	Body lengthened behind dorsal fin. No trace of larval fin-folds. Dorsal with 3 unbranched and 9 branched rays. 3rd unbranched ray thicker than the rest, by an ossification which sets in from a size of 13·8–14·0 mm. (text-fig. 3.) Pectorals with 10–12 and pelvics with 7-8 rays. Caudal deeply forked.	Stouter body with depth behind head proportionately greater; fins longer with full complement of rays as found in adults.	Body very much like that of an adult.
Tubercles on snout in 2-3 rows.	Tubercles much more prominent.	Tubercles have disappeared.	....
....	....	Scales visible behind opercle and on caudal portion.	Scales covering the entire body. Lateral line visible.
No trace of yolk. Intestine straight. Larvae actively feeding upon plankton.	First looping of intestine visible.	....	....
....	....	Continuous nature of lower lip with a small backward projecting lobe visible.	Lobe on the lower lip much more prominent.
....	....	....	Both pair of barbels present, appearing between 27·0–29·0 mm.
Pigment spots as shown in figure. Dark spot on the base of caudal.	Distribution of outer chromatophores is as shown in the figures. Caudal spot persists till the young attain a size of 110–120 mm.		

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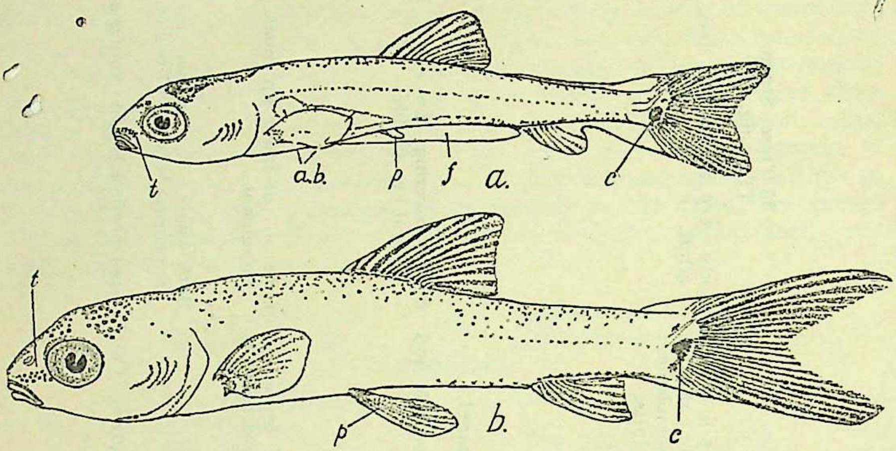
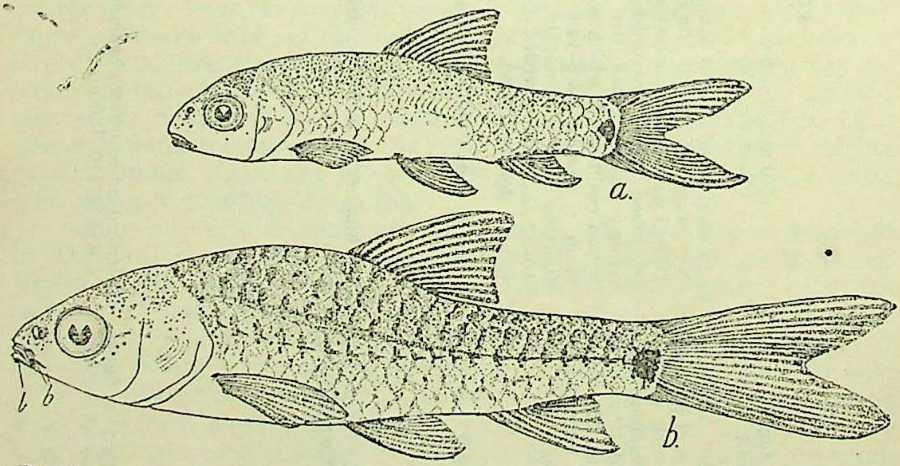


TEXT-FIG. 1.

a. 10·4 mm. post-larva. ×16.
b. 15·0 mm. post-larva. ×16.
t = tubercles; *p* = pelvic fin; *c* = caudal spot.



TEXT-FIG. 2.

a. 23·0 mm. post-larva. ×9.
b. 35·0 mm. fry. ×9.
l = labial fold of the lower lip; *b* = barbels.

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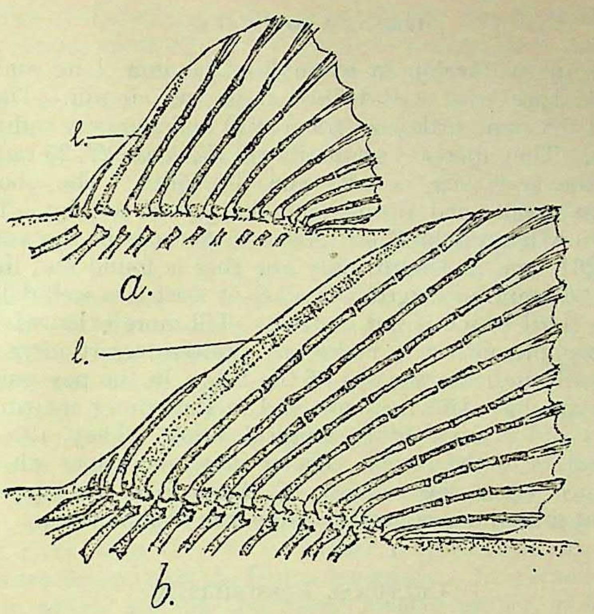
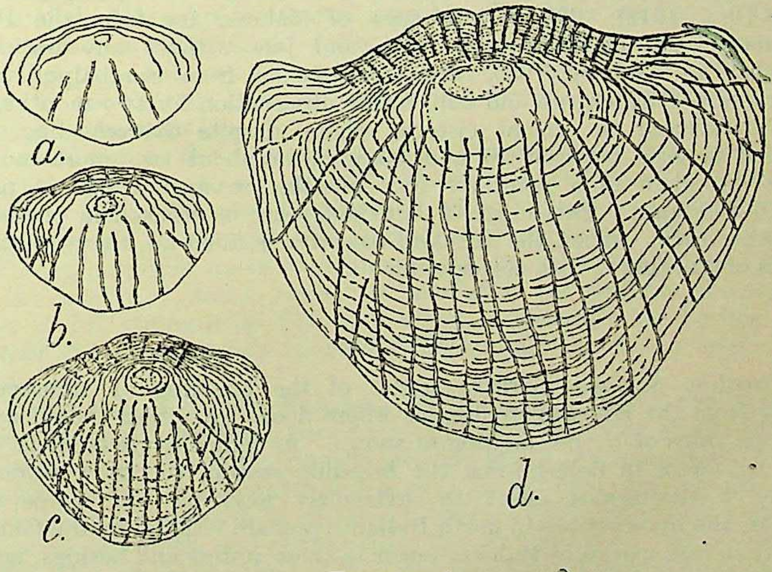


TEXT-FIG. 3.

a. Dorsal fin showing the last (3rd) unbranched ray—(*l*) still unossified in a post-larva of 13·0 mm. in length. ×30.

b. Dorsal fin showing the last (4th) unbranched ray—(*l*) well ossified and thick in a post-larva of 19·0 mm. in length. ×30.



TEXT-FIG. 4.

a.	Scale from a 22·5 mm. long post-larva.	×40.	Size of scale 0·8 × 0·55 mm.
b.	Scale from a 25·0 mm. long post-larva.	×40.	Size of scale 0·85 × 0·63 mm.
c.	Scale from a 28·0 mm. long post-larva.	×40.	Size of scale 1·1 × 0·87 mm.
d.	Scale from a 35·0 mm. long fry.	×40.	Size of scale 2·25 × 1·87 mm.

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Growth of Scales

Scales begin to develop in examples 22·5 mm. long and are of the simple cycloid type with well-defined radii and circulii. There are only 3–4 circulii at 0·8 mm. scale size (in width) and as many radii as shown in text figure 4*a*. They increase gradually till there are 22–25 radii at 35 mm. stage when the scale size is 2·25 mm. in width. The above structure and shape are maintained throughout the growth of fry. There appear to be some growth rings in Mosal Mahseer, because in the scales of specimens up to 261 mm. in length, only one ring is found and in scales from specimens of 365 mm. in length, there are at least two well-defined rings in addition to a third which is not distinct. Till more exhaustive studies are made, it is too premature to make any positive assertions as to whether these rings really indicate the age of the fish. In the possession of largest known scales amongst Indian carps, and in the winter spawning activities, the Mahseers differ from other tropical fishes. They also inhabit the colder headwaters of the rivers. Under these conditions which have profound influence upon the biology of these fishes, it may perhaps be suggested that growth rings may be present in the Mahseers.

Cultural Possibilities

There are possibilities of growing this fish in standing waters as their fry are now known to occur in rivers in large numbers unlike other carps. Walker (1888) successfully, transplanted *B.* (*Tor*) *putitora* to the Kumaon Lakes. Smith (1944) and Hora and Ahmad (1946) have indicated how Katli, *Barbus* (*Lissochilus*) *hexagonolepis, B.* (*Tor*) *putitora* and *B.* (*Tor*) *tor* can be grown in standing waters in the Darjeeling Himalayas. Judging from the growth of Mahseer fry in the Mahanadi it cannot be stated that the slow growth of Mahseer precludes it from being cultured in ponds (*vide* Skene-Dhu, 1918). 600 various sizes of Mahseer fry from the Huma sanctuary, kept in small open trays and jars without any noticeable mortality in January 1950, were transported from Sambalpur to an aquarium in Barrackpore and kept under observation for two months, and later transferred to cement cisterns where, despite overcrowding, they attained lengths between 70 and 96 mm. in about two more months. These fry when in a pond for four months, reached a size of nearly 8″ (170–200 mm.). This suggests that the fry can be stocked in ponds like any other carp. When the Hirakud reservoir is filled up, there are possibilities of stocking it with this species.

Discussion

Breeding Season.—Earlier records of the breeding of Mahseer are mostly from the Himalayan streams where floods are either caused by the monsoon rains or by the melting of snows. As temperature is likely to be a strong factor in determining the breeding season, the snow water has usually a deleterious effect by extremely lowering the temperature. Further, the observations in north Indian rivers are vitiated by the fact that more than one species of Mahseer occur in these waters and besides, several other large scaled Mahseers have also been confused with the true Mahseer.

From the observations already recorded and from the present study it seems that in the Peninsular rivers the optimum conditions for breeding are attained during the cold months. Flood waters are not suitable for it because during the flood season the fish leaves its usual summer habitats.

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Significance of Tubercles on the Snout in the Young of the Mahanadi Mahseer.—In young specimens 10–17 mm. in length, there are 2-3 rows of tubercles, which disappear as they grow to larger sizes. According to Hora (during personal discussions), the main difference between the Khudree Mahseer of Peninsular India and the Mosal Mahseer of the Eastern Himalayas lies in the presence of the tubercles in the former and their absence in the latter. It would seem probable therefore that the Mahanadi Mahseer has characters of both the two forms, the tubercles being only present during the fry stage but disappearing with growth.

Migratory Movements.—It is generally believed that Mahseers ascend the rivers and hill streams for breeding. MacDonald (1948) has attributed these movements to the changes in temperature of water from season to season. The Mahanadi Mahseer is known to disappear from the Huma sanctuary when the water level in the river rises. This is also true of carps which breed in monsoon months. Since Mahseers spawn in post-monsoon months (at least in rivers not fed by snow at source) it is probable that they move upstream seeking more congenial surroundings during the monsoon trying to avoid their flooded summer haunts. That a large scale breeding can actually take place with greater advantage in the main course of the river itself than in its higher reaches, is shown by the fact that nurseries are located near the Huma sanctuary. Nevertheless, the possibility of some adults gaining the upper reaches earlier in the monsoon period and subsequently breeding there when floods have receded (Thomas, 1897) cannot be ruled out. The breeding Mahseers gradually moving into deeper pools of the main river may thus be explained. In this connection the author's find of well grown fry (43 mm. long) of Mahanadi Mahseer in isolated pools of a dried up hill stream at an elevation of 200–300 ft. above the Mahanadi riverbed (sketch map 1) may be of interest. This stream drains into the Mahanadi through a deep nullah at Ramedega village opposite Meriapara, where a second Mahseer sanctuary within the Hirakud stretch of the Mahanadi is situated some 15 miles above the Dam. Though no connection is maintained between the nullah and the main stream after November, local fishermen report that Mahseers are actually found in this stream at the time of floods in July and August, along with other carps breeding in the monsoon.

In addition to the seasonal migration as seen above, there seems to be a diurnal migration as was actually observed in the Huma sanctuary in November 1950. Whereas hundreds of Mahseers gather in the sanctuary during daytime, not a single fish is seen after nightfall. Well after daybreak they generally move in winter months in twos and threes upwards into the sanctuary, and in about an hour after the first few fish appear, gather in full strength by 7·00 a.m. which is generally the feeding time. Whether these movements take place in summer months as well, is not known.

Hirakud Dam and the Mahanadi Mahseer.—It is feared that with the completion of the Hirakud Dam there will be a depletion of the Mahseer population in the breeding grounds close to the Huma sanctuary, because there will be no running water in the main river during the dry months of the year as the water will be diverted through the Power-cum-Navigational channel to the right arm surrounding Thavarkud island (sketch maps 1 and 2). The natural marginal pools across the riverbed which act as nurseries and the Huma sanctuary itself will therefore be affected by the absence of any running water for about eight months in the year. The upper sanctuary at Meriapara will, however, totally disappear by submersion; as these two important sanctuaries of the Mahanadi hold the main stock of

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Mahseer population, which provides food as well as game, their protection to conserve the stock hardly needs emphasis. These aspects, however, are more fully discussed in a reference to the fishery requirements of the Hirakud Dam.

Acknowledgments

The author is grateful to Dr. T. J. Job for his encouragement in the course of this study, to Dr. S. L. Hora for confirmation of the identity of the fish as a variety of the Mosal Mahseer and for effecting many improvements in the paper and to Dr. S. Jones for critically examining early stages of the fish and the manuscript. The author is greatly indebted to Dr. H. Srinivasa Rao for the many improvements in the paper for publication. He is also greatly obliged to the authorities of the Hirakud Project, in particular to the Chief Engineer, Mr. S. Vasisth, and his Personal Assistant, Mr. M. B. Rangasamy, who gave him all the necessary facilities for transport and accommodation in the course of these investigations.

Summary

In the course of observations on the breeding and migration of the important fishes of the Mahanadi near the site of the Hirakud Dam, a new race of the Mosal Mahseer, *Barbus* (*Tor*) *mosal mahanadicus* was found to occur commonly within a 60-mile stretch of the river. Adults also gather at two temple sanctuaries, and nurseries containing large number of fry were located close to and below the Huma sanctuary and the Dam. During investigations extending over a year, it was found that even though sexually mature adult Mahseers contain partially developed gonads, breeding takes place only during the post-monsoon period between October and November. The more important distinguishing features of the post-larval stages of this Mahseer are described, and their migratory and breeding habits discussed.

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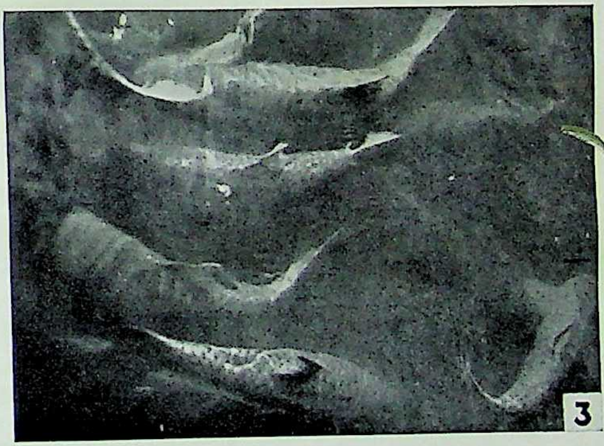

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PHOTOGRAPH 1

View of the Mahanadi near Mura village about 18 miles above the Hirakud Dam and some four miles above Meriapara Temple Sanctuary. This stretch will eventually get submerged by the reservoir.

PHOTOGRAPH 2

Another view of the Mahanadi at Sankhala village 16 miles below the Dam and about 6 miles above the Temple Sanctuary at Huma, before the bifurcation of the river (also refer sketch maps). This stretch will have no running water during dry months when the diversion of reservoir water through the Power Channel to the Lower Power House is accomplished.

PHOTOGRAPH 3

Mahanadi Mahseer feeding at the Huma Sanctuary. This Sanctuary will be affected adversely by the diversion of water through the Power Channel on the right bank of the right arm and the fish will probably disappear along with stoppage of running water.

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BOOK REVIEW

BULLETIN OF THE DEPARTMENT OF ANTHROPOLOGY, Vol. I, No.1, Edited by The Director, Department of Anthropology, Government of India, Calcutta, January 1952. Pages 1–159 with XIX plates. Price Rs.6-6-0 or 10 shillings.

Previous to 1946 Anthropology was included in the work under the Zoological Survey of India. In that year it was constituted an independent department and Dr. B. S. Guha was named Director. At the beginning of the second phase of World War II the Zoological Survey was transported from Calcutta to Banaras. After the war, in 1948, the newly constituted Department of Anthropology was returned to Calcutta. These shifts, together with the problems connected with a newly started Department, have delayed the publication of this their first Bulletin. In addition to this the Department aims to publish a series of Memoirs and also a number of short papers in popular form, written in various Indian languages. Several of these have already been published. It is hoped that from now on the publications of the Department of Anthropology will assume a regular and systematic course. Materials are in hand for Memoirs and other publications. The Department is to be commended on its proposals and it is hoped that there will be no undue delay in putting these plans into operation.

The first number of the Bulletin contains ten studies of varying lengths and values. Dr. Guha gives a brief report (seven pages) of a preliminary survey made of the inhabitants of the Andamans and Nicobar Islands during 1948-49. Unfortunately the lack of adequate transportation together with language difficulties prevented the collection of many things which they had hoped to secure and much more needs to be done before any conclusions can be drawn. There are seven interesting plates, which, however, are poorly printed. A serious lack is a map showing the relationships of the places visited. Since his visit four more have gone to the Islands from this staff and a great deal of material collected. A map is now ready. The article is written in the form of a travel diary. A subsequent article, No. 6 in the Bulletin, gives data of the blood groupings of the people whom they were able to contact: Onges, Andamanese and Nicobarese. This was collected early in 1948 by the Guha expedition and written up by S. S. Sarkar a member of the expedition.

There are three other articles dealing with the subject of blood groupings. Investigations are reported by S. S. Sarkar and D. K. Sen from the Santal Parganas. Blood types of five different groups are listed and analyzed: Santal, Mālé, Plains Mālé, Mālpaharia and 'other castes'. Uma Bose has two articles, one on the Bhils of Central India and another on blood groups of the tribes of Travancore. Comparisons are made with previous studies and in both cases conclusions are drawn as to racial affinities. The Bhils are classed among the 'Mundari stock' (p. 17) and the anthropometric data from the south 'show a close Veddoid ancestry and should be taken into consideration when comparing the Indian data with those of the distant Australians' (p. 23).

The sixth article is the 'Application of Performance Tests on the Bhils of Central India' and is written by U. Bose and P. C. Ray. It describes certain previous studies of performance tests, the environment of the

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Bhils, the method of approach and the types of tests, namely, Passalong, Dearborn, Cube construction and Block design. The results are compared and analyzed with the usual Psychometric methods. It is a valuable approach and needs to be carried out among other aboriginal groups in order that valid comparisons be made and adequate conclusions drawn.

The next three contributions are longer and contain new and valuable material. Verrier Elwin discusses the Saora Priestess (Kuranboi) and gives many biographical sketches and accounts of the manner of life of those women who have entered into a dedication to the office of one considered to be vitally in touch with supernatural affairs and who have a sense of knowing how to help the sick and afflicted. There are nine excellent plates, which, however, also suffer from inferior printing.

Uma Chowdhury writes on the Marriage Customs of the Santals and gives a detailed account of the intricate going-ons in Santal marriages. It is probably the best account published so far of this phase of the life of the Santal. The various kinds of marriages are listed and the significance of the marriage ceremony is evaluated.

The third contribution is entitled 'The Dharma-cult' and is presented by Ashutosh Bhattacharyya. It covers 37 pages and is a scholarly study of the Dharma Cult and its various relationships. There is a rich folk literature in connection with the cult and extracts are quoted. He sees a strong Proto-Australoid element in the worship which later on was much influenced by Buddhism and Hinduism. Dharma is the Supreme Being and is now identified with Sun worship. He demonstrates its intimate relationship with the Ḍoms and comes to the conclusion that the word 'Dharma' as used in the cult is 'undoubtedly a Sanskritized form of some Austro-Asiatic work meaning the Sun-god'. He declares that Ḍom is an Austro-Asiatic word and believes 'Dharma' may have developed in the following way: Ḍomrāya > Ḍomrā > Ḍormā > Ḍarmā > Dharma (p. 151). Whether or not this would be justified remains to be seen. The author shews wide acquaintance with the Sun worship of various primitive tribes and shows how, outside the area he discusses, the cult has lost most of its special features. The Reviewer found this true of Central India, where the Kols seem to have lost contact altogether and use the Sanskritized names of Sūryanārāyaṇa and Bhagawān. The name Dharma was not found.

The concluding article is a very sketchy survey of Indian Anthropological Literature in 1946-47. More careful proof-reading is called for and also perhaps, a less critical attitude toward the work done during those war years.

It would seem to the Reviewer that there ought to be a page indicating who the authors of the various articles are and giving something of their work.

On the whole the Department of Anthropology is to be congratulated on the presentation of this their first Bulletin. It is hoped that it will but be the first of many more valuable contributions to the study of Anthropology in India.

W. G. Griffiths.

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